tainable head of 18 ft., is rated at 250 HP. The total power of each set of turbines is, therefore, 1,000 HP. At present 5 units are in position, the two additional turbines will be installed later. The turbines for the exciters consist of three 18-in. Victor cylinder gate wheels, having, at 259 revolutions per minute a total of 300 HP.

Two draft tubes lead from each main turbine, the forward tube descending straight into the tail-

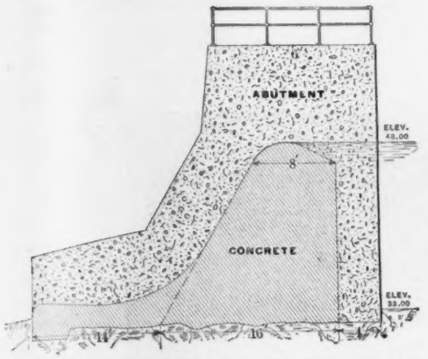


Fig. 1.—Section of Main Concrete Dam Showing Overfall and Section of Abutment.

race beneath the power house, the rear or up-stream tube curving and flaring downward and outward. Each tube is 9 ft. 6 ins. in diameter at the bottom. Two draft tubes are also allotted to each set of exciter wheels.

The speed of each set of main wheels is regulated by a Geisler electro-mechanical governor, mounted on a platform directly over the turbine shaft, and between the head wall and the generator. The use of electricity renders the mechanism of this governor extremely sensitive and effective, and the gates can be entirely opened or shut in 6 seconds should the full current be thrown on or off. The driving pulley is replaced by a rawhide pinion, giving a rigid connection between the governor and the wheel. The governor wheel speed may be increased to shut off or throw on in less than 6 seconds, if necessary. This type of governor is now in use in many of the most important electric power transmissions in this country, including those of Columbia, S. C.; Pulzer, N. C.; Lachine, Que.; West Kootenay, B. C., and Montmorency, Que. The exciter wheel gates are controlled by improved "Snow" governors. They are especially adapted to the regulation of water wheels driving exciters, and are provided with adjustable stops, which limit the hoisting action on the gate as soon as the gate is fully open.

Generators.—These are placed in a large well-lighted room, Fig. 6, 34×255 ft., and 30 ft. 5 ins. high in the clear, from floor to roof truss. The ultimate generator capacity of the station is 7,000 HP., in 7 generators, each of 750 K-W. capacity, although only 5 have been installed and are now running. These are uni-tooth, three-phase, 40-pole 750-K-W., 114-revolution alternating current machines, having revolving fields and stationary armatures. They are wound to deliver to the transmission lines, 36 amperes at a periodicity of 38 cycles and a pressure of 12,000 volts. They are arranged for operation in parallel at constant voltage. By using the revolving field type of generator it was possible to secure this high pressure directly from the machine without the use of step-up transformers. As the current is to drive synchronous and induction motors, to operate lights and to be converted into direct current through rotary converters, a frequency of about 40 cycles was selected as most suitable.

The alternators are similar in their main characteristics to those successfully used in the Lachine Rapids plant at Montreal; that is, the armature frame or ring is of the box type, 15 ft. 4 ins. in diameter and 36 ins. wide. It is bolted to a base 18 ft. 2 ins. long by 10 ft. wide, along which it may be moved parallel with the shaft, in order that the revolving field spider and poles may be uncovered should occasion arise. The field ring is bolted to the spokes of the spider and carries 40 poles each, securely fastened by two bolts to the ring. The whole revolves on a shaft 15 ins. in diameter, provided with a rigid bolt-coupling on the turbine side, which connects with the turbine shaft. The dynamo shaft is also extended at the other end for coupling to a vertical steam engine in case of necessity.

The following reasons for selecting this type of alternator have been given by Mr. C. P. Steinmetz of the General Electric Co.:

> In addition to the advantage which the stationary armature type has over the stationary field type in allowing a high transmission voltage to be taken directly from the armatures, it allows of a fairly low saturation of the magnetic circuit giving an almost straight saturation curve. This is preferable in power transmission, since a considerable increase in the voltage may be obtained if needed to cover excessive drop in the lines due to heavy loads, and the voltage may be maintained even if the speed remains low.

The exciters for magnetizing the fields of the generators are placed one on each side of the stairway leading to the switchboard gallery. They are 6-pole, 100-K-W., 125-volt standard General Electric machines with ribbed field frame and iron-clad armatures.

Switchboard.—The switchboard is erected on a gallery on the north wall of the dynamo room, and is built up of nine polished blue Vermont marble panels, each 7 ft. 6 ins. × 3 ft. and 2 ins. thick. Five are used for the generators and two for the feeders; one is the total output panel and the last is for the control of the exciters. The generator panels occupy the left side of the board, and space is left for two additional panels. The feeder panels are on the right side; the total output panel is between these and the generator panels.

Each generator panel is equipped with one inclined coil alternating ammeter reading to 75 amperes for the armature, and one direct current ammeter reading to 150 amperes for the field. Above each of these is a pilot lamp and a synchronizing lamp. Beneath the two ammeters is an inclined coil voltmeter reading to 15,000 volts, and beneath this instrument are three single-blade, double-throw, quick-break, high-tension switches, which are each mounted upon pyramids of corrugated hard rubber. Similar pyramids intervene at the back of the board between the bus-bars and the boards. The corrugations give a total distance of about 8 ins. of surface between the metal clips and hinge and the surface of the marble on each side. As these switches are to break current of 12,000 volts they are tested to break without difficulty currents of 21,000 volts. For safety the switches are made without handles, an eye being made in the end of each blade, into which a hook at the end of a stick may be inserted and the switch opened by the attendant from a safe distance. Further, to prevent any dangerous arcing from blade to blade, marble barriers 1¼ ins. thick, 3 ins. long and 12 ins. wide, from the face of the board are erected between the blades.

On the left hand side of each generator panel sub-base are two 100-ampere, double-pole, double-throw, carbon-break switches—one the field switch, the other the lighting switch. On the back of the panels are the high tension fuse blocks.

These fuse blocks, designed for 20,000 volts, are of the snap break expulsion type. They are mounted on pyramids of corrugated hard rubber, which contain copper spring contact clips between which the two copper blades on the block enter, connecting the fuse block to the line. The aluminum fuse is held tightly between two arms which are movable around a pivot and may be pulled apart by two strong spiral springs encircling this pivot. As soon as an increase of current in the line melts the fuse, its two halves are instantly pulled apart, thus preventing the formation of an arc between the two halves. The melting of the

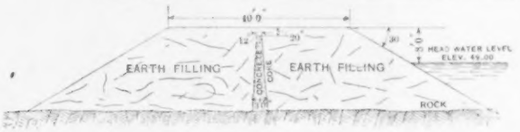


Fig. 3.—Section of Earth Embankment Forming Roadway.

fuse can only occur in a small chamber protected by wooden blocks. The whole fuse block is inserted in the line by simply pushing the two blade-like copper contacts between the clip contacts, which are connected by solid copper rods to the bus-bars. The field rheostats are hung beneath the gallery, and are operated by hand wheels conveniently placed on the gallery.

The exciter panel controlling the two direct current exciters carries two pilot lamps, two circular dial ammeters, each reading to 1,000 amperes, one volt-meter reading to 150 volts, one four-point pressure switch, one synchronizing switch, two 880-ampere, triple-blade, double-throw, equal-

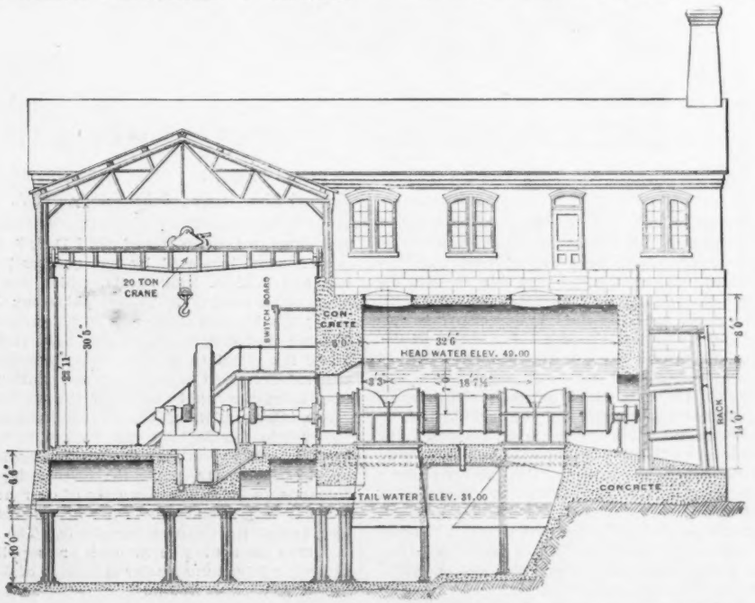


Fig. 5.—SECTION OF POWER HOUSE SHOWING TURBINES, DRAFT TUBES, GENERATORS, ETC.

izer switches and two packed cord rheostats placed at the rear.

The two feeder panels are alike in every respect, and each outgoing line is provided with an independent ammeter reading to 150 amperes, and a quick-break, double-throw, high-tension switch similar to those on the generator panels, and similarly mounted on the board. Mounted also on corrugated hard rubber pyramids are the six circuit breakers or automatic plunger switches, which are a special form of quick-break, non-arcing switches. A rocker arm controls the three switches for each set of bus-bars, so that they may

be all released at once. On the upper part of each feeder panel at the back is a current transformer for each outgoing line, two recording single-phase watt meters, each reading to 25 amperes and 12,000 volts and two potential transformers. On the front of the output panel are 2 Thomson recording watt meters for balanced three-phase circuits, each reading to 300 amperes and 12,000 volts and 12 triple-pole, single-throw 100 ampere switches with fuses for the lighting circuits. On the back are 4 potential and 2 current transformers.

The lightning arresters are of the G. E. short gap type, similar to those installed on nearly all now considered necessary, and is artificially brought into the line in the shape of reactive coils in cases where the natural self-induction is too small. The circuits are carried on poles, 30 to 60 ft. long, and all 8 ins. in diameter at the top. Each pole carries one cross arm, on one side of which are two porcelain insulators of the triple petticoated type, a third being on the other side. For lightning protection a barbed wire, frequently grounded, runs along the tops of the poles.

The line takes a westerly direction to East Glenville, and then due south to Schenectady. At the end of the Glenville bridge over the Mohawk, the town limits, it is carried down to the ground and

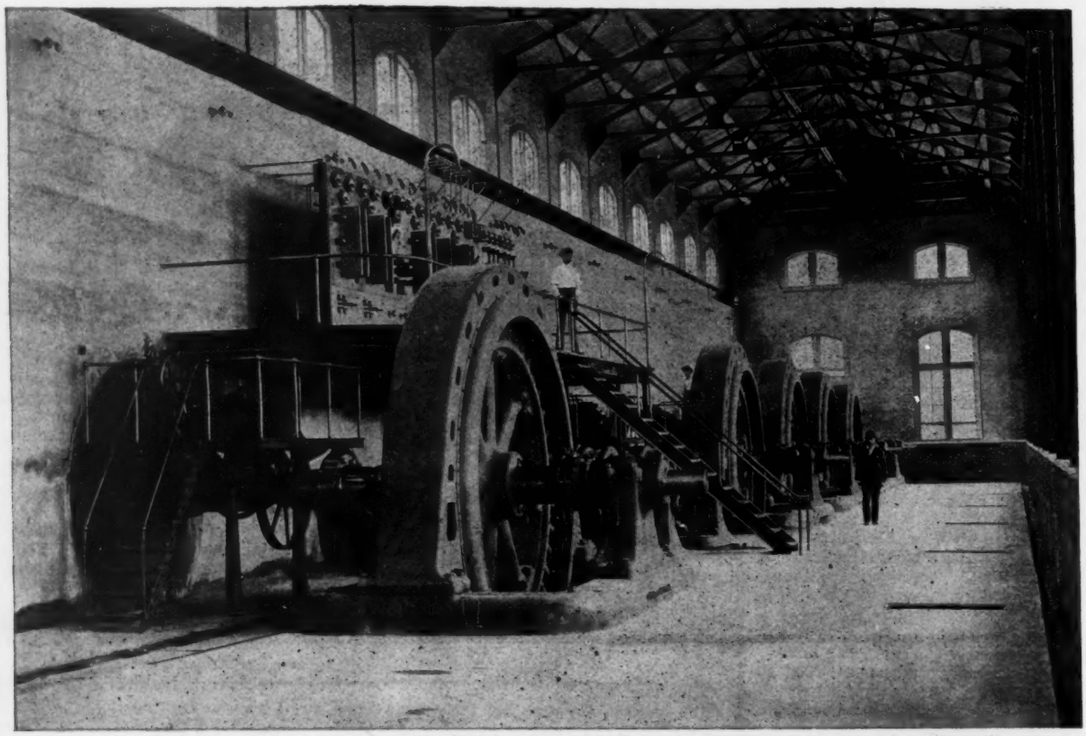


Fig. 6.—INTERIOR OF DYNAMO ROOM SHOWING FIVE THREE-PHASE GENERATORS, SWITCHBOARD, ETC.
General Electric Co., Schenectady, N. Y., Builders.

of the important long distance transmission lines in this country which have proved most satisfactory. It will be remembered that this arrester allows the passage of any high potential discharge, but effectually prevents the line current from following and maintaining an arc. The action of the arrester is dependent upon the cooling effect of two metal cylinders, 2 ins. in diameter and 2 ins long, placed 1-32d-in. apart, aided by the reversal of the alternating current and the introduction of a low non-inductive resistance, composed of graphite rods. The line is protected by double-pole 2,000-volt arresters connected 6 in series to give the necessary number of spark gaps. There are 3 sets of these; one at Mechanicsville, grouped around the first transmission pole in a small house 15 ft. square, one set where the overhead pole line connects with the underground cable and the third at the General Electric works.

The lead covered cables from the generators are taken out at the base of the machine, and are laid in ducts in the floor. The cables rise on a frame from the floor duct to the switchboard on the gallery, from the back of which the line wires rise to supports bolted to the I-beam on the north wall, which supports one of the crane runways, and thence around the building part way and out.

The transmission line from Mechanicsville to Schenectady is the only one in place at present. It consists of three No. 000 B. & S. bare wire, this large gage being employed in order to give the line as high self-induction as possible. The insertion of self-induction in transmission lines is a departure from earlier practice. In cases where synchronizing apparatus is used, self-induction is connected to three cables of No. 1 B. & S. stranded copper wire, insulated by one-quarter-inch rubber and 3-32-in. lead sheets, which are laid in terra cotta conduits. These cables run 1,700 ft. along Washington Ave., rise to poles again, pass through Rotterdam St. to the Erie Canal, and along the canal to a point directly opposite the General Electric Company's power station. They then cross the canal and enter the works.

The introduction of this transmitted electrical power into this factory will work a considerable change. At present all the machinery is driven by electric motors, while the testing department demands an independent supply of current for the work it carries on. There are at present, therefore, two distinct generating plants. The 550-volt motors in the testing department are supplied from an engine driven multipolar generator of 500 K-W. capacity, while a smaller engine drives a number of exciters, which allow of independent control of the excitation of all machines in this department. The factory is operated by a number of 250-volt motors running on the same circuit as the factory lights. These motors will not be changed, and the steam plant which supplies them will be retained as a reserve in case the power from Mechanicsville should fail. The electric power plant superseding the present steam plant at the works will, therefore, consist of two synchronous motors, one of 500 K-W., the other of 100-K-W., and three 400-K-W. rotary converters —the synchronous motors for the testing department, the converters to supply current to the factory motors.

The large engine driving the 500-K-W. multipolar generator is superseded by the 500-K-W. synchronous motors. This is a 12-pole, 400-revolution machine of the revolving field type, wound directly for 10,000 volts. The small engine driving the exciters is replaced by the 100-K-W. synchronous motor—an 8-pole, 600-R. P. M. revolving field machine similarly wound. This disposition renders the testing department independent of everything but the speed of the Mechanicsville generators which will be kept as nearly constant as possible.

The three rotaries supplying 250-volt current to the factory motors are 10-pole, 400-K-W., 480-R. P. M. machines, having two commutators and two sets of collector rings, connected to independent windings on the armature. They receive the three-phase current from independent secondary coils of the same set of air blast transformers. When connected in multiple they furnish current at normal pressure of 250 volts, but as they may be called upon to furnish current to the testing department, in case the demand exceeds the supply from the synchronous motor driven machine, they may be connected in series to give 500-volt current, operating in parallel with the railway generator, driven by the synchronous motor in the testing department. Synchronous motors were selected in preference to induction motors on account of, first, their more constant speed and greater efficiency; second, because they do not produce lagging currents, but the phase displacement and power factors may be controlled as desired by means of controlling the field excitation. It is also a fact that synchronous motors of the revolving field type and of good design are self-starting even under heavy load, and will easily carry two or three times full load without falling out of step for a time, which is limited only by the heating of the motor.

The entire construction of the dams, power house and lines has been carried out by the National Contracting Company, of which G. M. Furman is general manager. Mr. R. A. Mathews, superintendent, and J. A. Leonard, constructing engineer. The electrical equipment is furnished by the General Electric Company and the hydraulic equipment by the Stillwell-Bierce & Smith-Vaile Co., of Dayton, O., to which company was confided the entire development contract. It took the Hudson

River in its natural condition and turned over to the operating company the plant in running order.

The officers of the Hudson River Power Transmission Company are: General Edmund Hayes, of Buffalo, N. Y., president; R. N. King, president of Stillwell-Bierce & Smith-Valle Co., of Dayton, O., vice-president; G. M. Furman, Newark, N. J., treasurer; Mr. E. J. Richards, Boston, Mass., superintendent; J. S. O'Shea, manager.

Our acknowledgments are due to the General Electric Co. for the cuts and information made use of in the preparation of this article.

SEWAGE PURIFICATION BY INTERMITTENT FILTRATION AT CENTRAL FALLS, R. I.

The city of Central Falls, R. I., has an estimated population of 16,000, compactly located on an area of only 1.3 square miles. A public water supply was introduced in a portion of this territory in 1879, the city having been formed only a few years ago. Sewers were first put in operation in 1889. The sewerage system is divided into two districts. The larger of these districts was the first to be provided with sewers, the contents of which are discharged into the Blackstone River without treatment. At the close of 1897 this district had about 6¼ miles of sewers, and 374 house connections.

In 1893, a report on a sewerage system for the second, or western district, was made by Mr. S. M. Gray, M. Am. Soc. C. E., of Providence. Mr. Gray recommended the construction of both sanitary and storm sewers, but on the separate plan, the sewage proper to be treated by chemical precipitation. In 1894, Mr. L. C. Heywood, the engineer for the town of Lincoln, from which the city of Central Falls was afterwards set off, recommended combined sewers, with disposal by intermittent filtration, advising the present location for filter beds. The sewers were begun under Mr. Heywood, who died in January, 1895, and was succeeded by Mr. Wm. Faitoute Keene, Assoc. M. Am. Soc. C. E., the present city engineer, before more was done about the filter beds than to buy the land. Mr. Keene designed the settling basins and filter beds now in use and they were also built under his direction as city engineer. The effluent from the beds, together with the storm overflow, discharges into the Moshassuck River, which empties into the head of Narragansett Bay.

About Sept. 1, 1896, the sewers and filter beds were put in use. At the close of 1897 there were about 1½ miles of sewers in the district, including the outlet, with 87 house connections, serving 101 houses. On June 11, 1898, the number of connections had increased to 98 and these gave service to 112 houses. Each house in this district had an average of about ten inhabitants by the census of 1895.

The lower portion of the outlet is a 60 × 90-in. brick sewer, of horseshoe shape, 863 ft. in length, with a grade of 0.1 ft. in 100 ft. There has been trouble with sand in the invert of this sewer, which has reached a depth of 1 ft. between periods of removal. At the lower end of the outlet sewer there is an automatic device by means of which the entire flow may be shut off from the beds during heavy rains. This device consists of a brick well, 5 ft. square inside, with a 12-inlet from the brick sewer, and two 12-in. outlets, one of which is the overflow. The regulating is done by a float connected with a shut-off gate on the trestle pipe line, mentioned below, so arranged that when the float reaches a certain height the gate closes, and the sewage runs through to the overflow pipe.

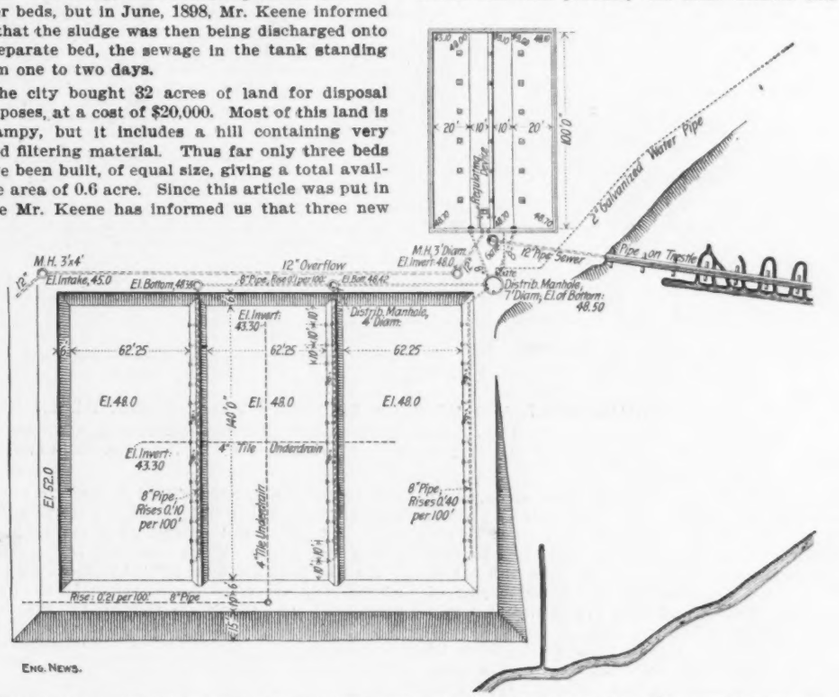
The sewage is conveyed from the end of the brick outlet across the swamp to the settling tanks and beds through a 12-in. Akron pipe on a timber trestle. The pipe is in 2-ft. lengths, with yarn and cement joints. Settlement of the trestle was expected and provided for, but the settlement has been greater than was expected. The trestle was built only for temporary use.

Two settling tanks are provided, near the beds, as shown by the plan. This plan gives the principal dimensions of the tanks, beds and accessories, with the exception of the available depth of the tanks, which is 40 ins.

Only one of the two settling tanks is used at present. Each tank has an available capacity, for purposes of sedimentation, of 70,000 gallons. Both tanks are floored over and have a roof forming a one-story building. Part of the enclosed space is used for a gage room and office, and the remainder for the storage of sprinkling wagons and other city property. Beneath the gage room is a small receiving and regulating tank for each of the settling tanks.

When the plant was visited in November, 1897, by a member of the editorial staff of this journal, the practice was to discharge the one tank in use when the sewage in it had accumulated to a depth of 25 ins., or about once in two or three days. The sludge was then being turned onto the filter beds, but in June, 1898, Mr. Keene informed us that the sludge was then being discharged onto a separate bed, the sewage in the tank standing from one to two days.

The city bought 32 acres of land for disposal purposes, at a cost of $20,000. Most of this land is swampy, but it includes a hill containing very good filtering material. Thus far only three beds have been built, of equal size, giving a total available area of 0.6 acre. Since this article was put in type Mr. Keene has informed us that three new beds are under construction, each with an area of 0.2 acre. No chemical analyses of the sand have ever been made.



PLAN OF SETTLING TANKS AND FILTER BEDS FOR THE SEWAGE DISPOSAL WORKS OF CENTRAL FALLS, R. I.
Wm. Faitoute Keene, City Engineer.

The total amount of sewage treated during 1897 was 4,042,721 gallons, or an average of about 11,700 gallons a day. This, on an area of 0.6 acre, is equal to about 19,500 gallons per acre per day. Mr. Keene places the flow of sewage in June, 1898, at about 20,000 gallons a day, and states that the sewage is very strong, as no ground water enters the sewers. He says that in consideration of the fact that authorities allow one acre for each 1,000 inhabitants, and their 0.6 acre is treating the sewage from 1,120 people, he does not think the rate is a low one. According to his figures the flow is now nearly double the average for the year 1897, being at the rate of about 33,000 gallons per acre per day.

One man is stationed at the beds for the purpose of caring for them and recording the amount of sewage treated, together with the temperature of both air and sewage. In November, 1897, the beds were found to be nicely graded and everything appeared to be in good condition. The sand is light in color, giving the beds a unique appearance. The embankments are of sand and have not yet been covered with grass. The sand was handled for about 12 cts. per cu. yd. The total cost of the plant, including the trestle across the swamp, but not including land, has been about $10,000 thus far. The unit cost will be diminished as the disposal works are extended. We are indebted to Mr. Keene for courtesies extended during the visit of our representative to the plant, and for drawings, reports and notes furnished to us.

THE FIRST RAILWAY IN KOREA.

The American victories in the Philippine Islands will undoubtedly have an important result in calling attention to American commercial movements in the Far East and in promoting our foreign commercial interests. In a recent issue we described some of the work done by Americans in the Hawaiian Islands, and we are now able to present some interesting particulars of the railway which is being built in the little empire of Korea by the Seoul & Chemulpo Ry. Co., under a concession granted in 1893 to Mr. James R. Morse, president of the American Trading Co., of New York city. Until within the past few years, Korea has been probably the most isolated and self-dependent state in the world, having few relations with other countries and being practically devoid of all the improvements of modern civilization, but the advent of the railway will undoubtedly lead to the opening up of the country for foreign trade.

The railway will extend from the port of Chemulpo to the capital city of Seoul, a distance of about 25 miles, but it will not be completed until early in 1899. Delays in the construction have been caused by the owners recently deciding upon extensive changes in reducing the maximum grade from 2% to 1%, and decreasing the mimimum curvature from 8° to 6°. Other delays have occurred in reclaiming from the sea all the land necessary for extensive terminals at Chemulpo, necessitating the construction of a strong seawall and much filling in on the foreshore. The line will pass through a country composed of valleys and small hills, the highest and lowest elevations or summits being 146 ft. and 35 ft. For two-thirds of its length the line will pass through rice fields. The traffic will consist largely of rice, beans, coal and general freight. The gage is 4 ft. 8½ ins., which is the same as that of the Chinese railways, except that the new Manchurian Railway will be of the Russian standard gage of 5 ft., being an extension of the Trans-Siberian Ry. It is expected that eventually a line will be built northward from Seoul to connect with the Manchurian line, or with the North China Ry. from Pekin.

There are no very important engineering works, with the exception of a steel truss bridge 2,063 ft. long, having ten equal spans, which crosses the Han River four miles south of Seoul. This bridge

was built by the Universal Construction Co., of Chicago, (Illinois Steel Co.). Timber trestles are used for other crossings, and it is probable that these will be replaced by steel structures in the near future. There are no tunnels, and the materials encountered in excavation are mainly granite, decomposed granite, clay and loam. The American-Oriental Construction Co. has the contract for construction, and most of the work is done by small sub-contracts; Korean, Japanese and Chinese laborers being employed.

The track is laid with 56-lb. rails, rolled by the Illinois Steel Co., the joints being spliced by soft steel angle-bars with four bolts. The ties are of Korean and Japanese timber, similar to pine of moderate quality, and there are 15 ties to a rail. The ballast is of broken stone.

The equipment includes four locomotives, 20 passenger cars and 100 freight cars. The locomotives are tank engines of the mogul type, built by the Brooks Locomotive Works, of Dunkirk, N. Y., and one of these was illustrated in our issue of Feb. 24. The cars are of the American type, and most of them were made by the Jackson & Sharp Co., of Wilmington, Del.

For the information respecting this railway we are indebted to Mr. D. H. Colibran, of the American-Oriental Construction Co. (formerly of the Colorado Midland Ry.), who is in charge of the company's interest in Korea. Mr. Colibran has the concession for an electric railway at Seoul, and five miles of 25-lb. rails for this line have been shipped from this country. He is also negotiating for a concession for the electric lighting of that city.

THE DAVIS AVENUE CANTILEVER HIGHWAY BRIDGE, ALLEGHENY CITY, PA.

We illustrate herewith the strain sheet and some of the more important details of a cantilever highway bridge now being built to span a deep ravine which intercepts the approach to Riverview Park, in the city of Allegheny, Pa. The park has an area of about 250 acres, and is being rapidly improved by drives and footpaths. It is situated in the northern part of the city, and at present is reached by only two main streets from the center of the city. The bridge illustrated is designed to give access to the western portion of the park from all that portion of the city lying to the north and west. A road along the bottom of the ravine, which the bridge crosses, also gives access to the western end of the park. The contract for building the bridge has been let to Mr. Gustave Kaufman, M. Am. Soc. C. E., of Pittsburg, Pa., for $25,754.

The illustrations explain quite fully the principal structural features of the bridge, and only a few of the minor details need to be mentioned here. Fig. 1 shows the strains and composition of the different truss members; Fig. 2, a half transverse section disclosing the latticed floor beams and stringer and floor construction, and Fig. 3, details of the abutment anchorages. As will be seen, the roadway is carried by seven lines of intermediate stringers and two guard rail stringers, and each sidewalk by one intermediate stringer and an outside stringer. The intermediate roadway stringers are rolled I-beams, but the sidewalk and guard rail stringers are made up of plates and angles. These stringers rest on top of the floor beams and are riveted to them. On top of the stringers come buckle-plates ¼-in. thick arched 2½ ins., which are riveted to the top flanges of the I-beams with rivets to be spaced not more than 5 ins. apart. These buckle plates sustain the floor covering of concrete and asphalt paving. The specifications call for a thickness of 2½ ins. of concrete over the highest part of the buckle plates, the concrete to consist of Portland cement, clean, sharp sand, and 1½ in. broken stone. The paving of asphalt will be 1½ ins. thick.

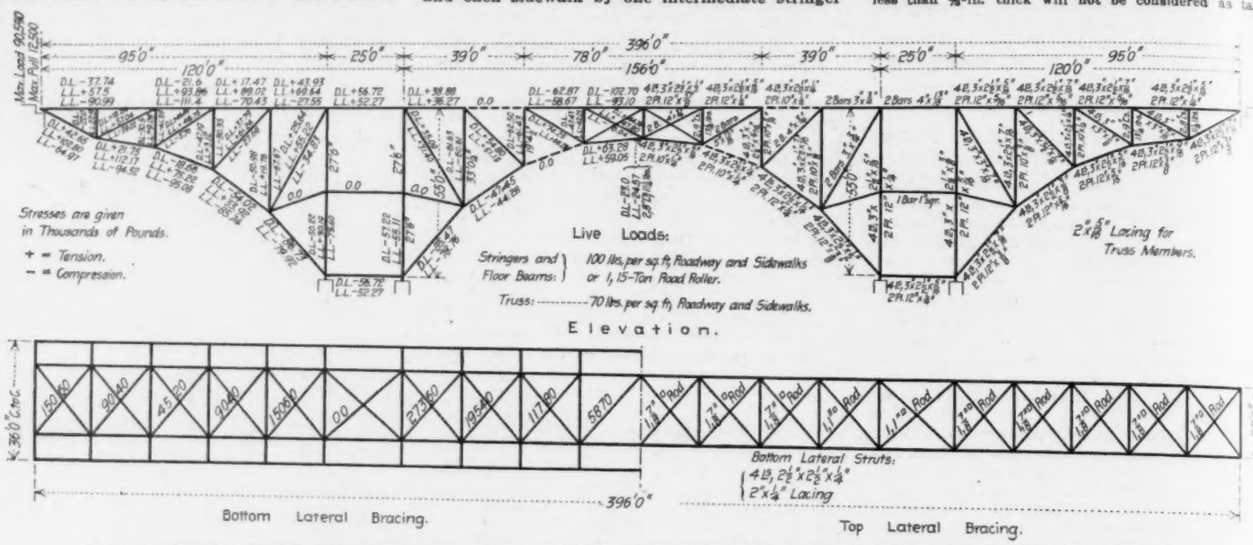

Stresses are given in Thousands of Pounds.
+ = Tension.
− = Compression.
Live Loads:
Stringers and Floor Beams: 100 lbs. per sq. ft. Roadway and Sidewalks or 1, 15-Ton Road Roller.
Truss: 70 lbs. per sq. ft. Roadway and Sidewalks.
Elevation.
Bottom Lateral Bracing.
Top Lateral Bracing.
Bottom Lateral Struts:
2"x¼" Lacing for Truss Members.

FIG. 1.—STRAIN SHEET AND MAKE UP DIAGRAM, DAVIS AVE. CANTILEVER HIGHWAY BRIDGE, ALLEGHENY CITY, PA.
D. L. Fulton, Superintendent Highways and Sewers, Allegheny City, Pa.
Gustave Kaufman M. Am. Soc. C. E., Pittsburg, Pa., Contractor.

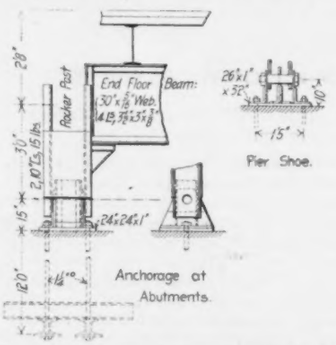


Fig. 3.—Abutment Anchorages, Davis Ave. Bridge.

All parts of the bridge will be of steel except the lateral rods and welded parts, which will be of wrought iron. The various members were designed so that the following unit strains would not be exceeded:

Bearing on shop rivets	15,000 lbs.
" " field "	12,000 "
Shearing on shop rivets and pins	7,500 "
" " field "	6,000 "
" " pin plates	6,000 "
Binding on pins	20,000 "
Bearing " "	18,000 "

For wind stresses an addition of 25% was made to the above unit strains. In regard to riveted work the specifications contained the following requirements:

Rivets will not be less than ¾-in. in diameter. Direct tension on rivet heads shall be avoided. The pitch of rivets shall in no case exceed 6 ins., nor be less than three diameters of the rivet. At the ends of compression members the pitch shall be four rivet diameters for a length equal to twice the total width of member. The effective diameter of a driven rivet shall be assumed the same as its diameter before driving. Where practicable, the distance from edge of any piece to center of rivet shall be two diameters of rivet. The shearing or bearing value of countersunk rivets in plate ⅜ to ⅝-in. thick will be taken as one-half the full value. Countersunk rivets in plates less than ⅜-in. thick will not be considered as taking any of the stress, and in plates ⅝-in. thick or over the regular value shall be used. In deducting rivet holes to obtain the net section in tension the rivet hole will be taken with a diameter of ⅛-in. larger than the undriven rivet for rivets with full heads and ¼-in. larger for countersunk rivets. All rivet holes shall be punched 1-16-in. larger in diameter than the diameter of rivet to be used.

The requirements for workmanship called for first-class methods and finish, but present nothing unusual. In regard to the material, the specifications state that,

All steel must be uniform in quality and must be made by the open-hearth process. It shall contain not more than 0.08% phosphorous in the finished product, and shall have an ultimate tensile strength of not less than 56,000 lbs. nor more than 64,000 lbs. per sq. in.; an elastic limit of not less than 30,000 lbs. per sq. in.; an elongation in 8 ins. of not less than 25%, and shall show a reduction in area at the point of fracture of not less than 45%. Steel for rivets shall have an ultimate strength of from 48,000 lbs. to 58,000 lbs. per sq. in.; an elastic limit of not less than one-half the ultimate strength; an elongation of 28% in 8 ins., and a reduction of area of not less than 50% at the point of fracture.

The usual bending, hammer and drifting tests were required of all steel. For the information from which this description has been prepared we are indebted to Mr. D. L. Fulton, Superintendent, Bureau of Highways and Sewers, Allegheny City, Pa.

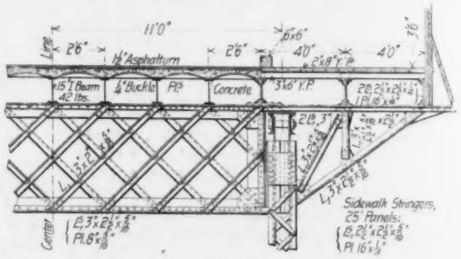


Fig. 2.—Transverse Section of Davis Ave. Bridge, Showing Sidewalk and Floor Construction.

A SMOKE INSPECTION SYSTEM has been installed at Pittsburg, with Mr. Jas. J. Brennan as chief inspector. From local press reports it appears that the work at the start will be largely of an advisory character.

THE CONDUIT ELECTRIC RAILWAYS of Washington, D. C., had to shut down on Aug. 12, owing to a severe rain storm, which flooded the conduits and short circuited the conductor rails, causing in some cases a delay of several hours.

THE BOSTON ELECTRIC SUBWAY ran its first regular passenger car over the entire line on Aug. 19. The American Society for the Advancement of Science was holding its annual meeting in Boston, and members of the Section for the Promotion of Engineering Education were the first passengers.

THE NEW YORK STATE COLLEGE OF FORESTRY, at Cornell University, was established by Act of Legislature in April, 1898, and this act authorized the trustees of Cornell to create a department in the University with the above name; establish a demonstrative forest of 30,000 acres in the Adirondacks, which was to be the property of Cornell University for 30 years, and appropriated the sum of $10,000 for the organization and maintenance of this "College Forest." The object of the College of Forestry is to furnish instruction in the principles and practice of forestry and to especially educate managers of forest properties. This college has now been organized, with a full faculty and with Mr. Jacob Gould Schurman as its President. The college year begins on Sept. 22 and closes on June 22, with three terms in each year. A pamphlet has been issued setting forth the requirements for admission, nature of studies and examinations, tuition fees, etc.; and this pamphlet can be obtained by addressing the Director of State College of Forestry, Ithica, N. Y. Tuition is free to students who are residents of New York. The degree issued on graduation is that of Bachelor of the Science of Forestry.

THE EAST BOSTON TUNNEL PROJECT is being discussed before the Rapid Transit Commission in Boston. No less than seven routes are proposed; though the one most favored is that having an opening on the Boston side at State St. or Adams Square and striking Lewis St., and Maverick Square, at the East Boston end. The commission believes that it is authorized to permit the construction of such a tunnel and the consent of the Secretary of War has been asked and a favorable answer is expected. The project is strongly opposed, however, by certain Boston interests. The chief argument used against it is the great first cost and the heavy expense of maintenance. These opponents say that the ferries will still have to be maintained, though their revenue will be reduced by the tunnel traffic; it would not connect with the subway system, and it would be impossible to concentrate existing traffic at the Boston end of the tunnel. The advocates of the tunnel are still to be heard from.

A NICARAGUAN FINE WOODS CONCESSION has just been made to Mr. H. C. Emery, of Chelsea, Mass., for 15 years. This is practically a renewal of an old concession to Mr. Emery under which he shipped about 12,500 logs annually. Mr. Emery is to build 50 miles of a 3½-ft. gage railway between Rio Grande and Pearl Lagoon, and this property is to revert to the government at the end of the concession. He pays $20,000 gold down and $10,000 per year in gold for 15 years. But his concession is said to be exceedingly valuable, as it gives him the monopoly in the shipping of mahogany, rosewood, cedar and other valuable woods; he has also the right to import, free of duty, all supplies for the men engaged in cutting wood and for building and maintaining this railway.

A PLAN TO DEVELOP THE WATER POWER of the Shawinigan Falls on the St. Maurice River, which is about 100 miles from Montreal, Canada, has taken definite form. The head obtainable is 165 ft. with a supply of water estimated to be sufficient to develop 200,000 HP. The Shawinigan Water Power Co. contemplates installing apparatus to utilize about 100,000 HP. Bids are now being asked for the hydraulic construction, as noted in our advertising columns.

THE IRON AND STEEL COMBINATIONS, which has been in process of organization in Chicago for some time, is now authoritatively said to include the following five companies: Minnesota Iron Co., with its Duluth & Iron Range Railway, and Minnesota Steamship Co.; Illinois Steel Co., with its Chicago, Lake Shore & Eastern Railway; Southwestern Connellsville Coke Co.; Elgin, Joliet & Eastern Railway; Lorain Steel Co., of Lorain, O., and the Johnstown Steel Co., of Johnstown, Pa., lately merged with the Lorain Co. The promotors of the combination still hope to later include the Cambria Iron Co., Bethlehem Iron Co., Tennessee Iron & Coal Co., Pennsylvania Steel Co., Colorado Fuel & Iron Co. and the Carnegie Steel Co. The capital of the new combination will probably be $200,000,000; and the five companies named as in the deal have a capitalization of more than $75,000,000; those named as still outside are capitalized at over $90,000,000. The Carnegie Co., however, officially denies having any connection whatever with this trust. The new company would be called the Federal Steel Co., and the syndicate to furnish working capital will be managed by J. P. Morgan & Co., says Judge E. H. Garry for the committee of ten on organization.

CUBA AND PORTO RICAN TRADE is already interesting American manufacturers and shippers. The ending of unstable conditions, bad credits, revolutions and generally unsatisfactory trade relations, existing under Spanish rule, is expected to largely develop the natural wealth and commerce of these islands. In 1893 the total Cuban trade with the United States was about $100,000,000, and $6,500,000 with Porto Rico. In the same year Spain's trade with Cuba was $34,000,000 and $8,700,000 with Porto Rico. Our exports to Cuba, in 1893, was $23,000,000, and business men believe it will be $50,000,000 within five years. More adequate transportation facilities are being already promoted; and Baltimore, among other points, is planning a new line of steamers for the West Indian trade.

THE SOO CANAL TRAFFIC for July last breaks all previous records. The freight tonnage amounted to 3,246,787 tons, as compared with 2,856,767 tons for July, 1897; an increase of 390,020 tons. This record includes both the U. S. and the Canadian canal; the registered tonnage being 2,331,062 for the 2,025 U. S. craft passing, and 314,043 tons for the 559 Canadian craft. The chief items of east-bound traffic were 1,558,564 bushels of grain, 2,055,574 net tons of iron ore, and 2,358,267 bushels of wheat. The total east-bound freight was 2,491,019 net tons, and the west-bound, chiefly coal, amounted to 755,768 net tons The traffic for June of this year was 2,949,465 net tons.

COINAGE DURING THE FISCAL YEAR of 1897 from the United States mint included a total of 102,521,641 coins, representing the following denominations: Gold, 170,473 double eagles, 724,562 eagles, 917,067 half eagles, 19,380 quarter eagles; silver, 4,158,780 dollars, 2,600,780 half dollars, 8,484,780 quarter dollars, and 12,560,780 dimes; base, 19,015,343 nickels and 53,871,696 pennies. The total value was $25,604,792.11, made up of $15,278,865 in gold, $8,836,443 in silver, and $1,489,484.11 in copper and nickel.

TULARE LAKE, in Tulare Co., once the largest body of fresh water in California, is now dried up. About 1872 the lake was about 80 miles long and 35 miles wide at the greatest width, but its depth was never great. Irrigation was introduced into this region in 1872-75, and as the water was drawn off from its tributaries the lake began to shrink in size. In 1895 the lake was only 4 to 5 miles wide; and though it remained stationary in its dimensions for some time, lack of rainfall and increased demands for irrigation upon its former tributaries have finally prevailed, and Lake Tulare has dried up. Farmers are now reclaiming the land and putting it into shape for cultivation, and channels are being made and gates put in to control the waters that a rainy season may send into the old lake basin.

THE BRUGES SHIP CANAL, now under construction in Belgium, was practically started in 1890, with the purpose of again connecting the town with the coast by a canal, with a port at Heyst. Work was actually commenced in 1896 by the Compagnie des Installations Maritimes de Bruges. The canal will be six miles long, 72½ ft. wide at bottom, 229 ft. at the water line and 26¼ ft. deep. The harbor will be formed by a long mole, running out from shore in a curve of 4,000 to 6,000 ft. radius; its end being parallel to the coast line and 2,788 ft. distant at low-water, and including an area of 270 acres. This jetty is solid to low-water mark; and then open for 984 ft. to facilitate the circulation of the tide and prevent deposits of silt and sand. From this opening to the end the jetty is being made of concrete blocks resting on iron caissons, each 82 ft. long by 24 ft. wide and varying in height with depth of water. These caissons are built on shore and floated to their sites, and then sunk by concrete in a dredged bed. The upper part of the concrete caisson blocks, each weighing from 2,500 to 3,000 tons, will be 3 ft. above low water, and on these will be placed 50-ton concrete blocks to a height of 28 ft. above high water. The lock at the end of the ship canal is controlled by a caisson-gate that can be slid into a recess at right angles to the canal in ten minutes, with electricity as a motive power. The work is to be completed in 1902, and the contract price is $7,793,805.

TWELVE RIVER STEAMERS, built by Moran Bros. Co., of Seattle, Wash., were lately successfully sent from that city to the Yukon River, in Alaska, a distance of about 4,000 miles by sea. These boats were each 175 ft. long, 35 ft. wide, with a molded bow and a depth of 6½ ft. They are propelled by a stern paddle-wheel, in two sections, operated by two direct-acting steam engines, with 20-in. cylinders and 7-ft. stroke. They are fitted with a complete electric lighting plant and search-lights. The hulls are built of Puget Sound fir and the general construction is that of the usual vessel of this type. These steamers were to be delivered ready for service at the mouth of the Yukon River, and the Moran Bros. Co. undertook the task of sending the flat-bottomed vessels 4,000 miles by sea, and they have performed this unprecedented feat. The boats were built exceptionably strong with this voyage in view, and the start was made from Roche Harbor about May 25, under Mr. Robert Moran, twice Mayor of Seattle, accompanied by three stout ocean towboats and five coal barges. St. Michaels, near the Yukon, was reached on July 26; but the fleet had passed through two heavy storms; one vessel of the fleet was totally wrecked, but without loss of life, and some of the captains and crews having been frightened off by the earlier experience, the trip was made shorthanded. The route lay along the coast line all the way; but owing to the able management of Capt. Moran, ten of the steamers were delivered in sound condition and the other had sustained slight injury only.

THE DISCHARGE OF THE GREAT LAKES is being determined by the U. S. Deep Waterway Commission, and Mr. Geo. Y. Wisner, M. Am. Soc. C. E., of the Commission, has furnished to the "Monthly Weather Review" the following summary of the results thus far obtained:

Lake Erie.—The discharge into Niagara River for mean lake level will probably prove to be about 235,000 or 240,000 cu. ft. per second (instead of 250,000).

Lake Superior.—The outflow, namely, the discharge through St. Mary's River, was determined in 1895, by Mr. Haskell, as 72,600 cu. ft. per second for mean lake level, instead of the 86,000 formerly adopted.

Lake Michigan plus Huron.—The discharge of the St. Clair River will probably be diminished proportionately, viz., about 10 or 12%, reducing it from 225,000 to 200,000.

Lake St. Clair.—The discharge of Lake St. Clair, through Detroit River, will fall below 200,000 cu. ft. per second for mean condition.

As regards the run-off for Lake Superior, a fair estimate for the watershed is 40%, as the country surrounding the lake is very rolling and rocky. For lakes Michigan, Huron and Erie, 33% is about right.

Adopting these values we have the following results:

Lake Superior.—Total supply, 4.2 ft.; total discharge, 2.6 ft.; leaving 1.6 ft. for evaporation and errors in the estimates.

Lake Huron plus Lake Michigan.—Total supply, 6.6 ft.; total discharge, 5.0 ft.; leaving 1.6 ft. for evaporation and errors in the estimates.

Lake St. Clair plus Lake Erie.—Total supply, 27.8 ft.; total discharge, 25.5 ft. (adopting 235,000 ft. per second), leaving 2.3 ft. for evaporation and errors in the estimates. Discharge for Lake Huron is probably less than 200,000, which would increase this excess by 20% above the estimate for Lake Huron and decrease that for Lake Erie.

Nothing more definite can be hoped for until the final report of the engineers who are now at work on the physics of the lakes and waterways.

GRANULATED BLAST-FURNACE SLAG BRICK is described by F. W. Luerman in "Stahl und Eisen." Brick made from fluid slag is unsuitable as a building material, as it is impermeable to air and makes walls damp and the house unhealthy, says the author. On the other hand, brick made from granulated slag is five times as permeable as ordinary burned brick and much stronger. The fluid slag is granulated by passing it through water, and the silica is separated in a soluble condition so that it hardens quickly in the air and combines easily with caustic lime. These bricks are compressed and not burned; hardening takes place in from 6 to 8 days when about 10% of burned and slack lime is added; but longer for the simple granulated slag. The color of the brick is that of grayish-white sandstone, and as little mortar as possible is used in laying them. The weight varies with the dryness; usually 6,000 bricks make a 20-ton carload. Well hardened slag bricks are claimed to withstand a crushing load of 160 to 180 lbs. per sq. in.; they resist high temperature exceedingly well, and they can be used to advantage in chimneys and stacks. As to absorption, an ordinary burned brick is said to fill its pores with water in 12 hours, while it takes 190 hours to soak thoroughly a slag brick. The best brick is said to be made from puddling and Thomas pig-iron slag; Bessemer and foundry slag rank second. The cost of the slag-brick plant is placed at $5,000; and at several German works the cost of the brick is as low as $2.38 per 1,000. For 1,000 bricks from 6,000 to 7,000 lbs. of slag and 450 to 700 lbs. of burned lime are required.

TO COUNTERACT THE EFFECT OF WATER upon lead pipe, Mr. Liebrich, in the "Zeitschrift fur angewandte Chemie," of July 26, recommends the use of carbonate of soda. He says the essential causes of this attack upon the lead are the joint action of oxygen, or of air and carbonic acid. The presence of bicarbonate of lime in the water limits the dissolving action by apparently interfering with the formation of carbonates of lead and zinc. Mr. Liebrich says that while the carbonate of lime diminishes the dissolvant action upon the metal, it does not arrest it completely. He, therefore, recommends the use of carbonate of soda, in a quantity that is sufficient to fix the carbonic acid, without rendering the water alkaline. He admits that when the water is in active circulation, as in the daytime, the quantity of lead in solution is extremely small; but he contends that in the morning, after the water has stood in the pipes all night, the dissolvant effect is very noticeable.

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The provision of special means for obtaining easy access to the superstructure of large bridges in order to perform the necessary work of inspection, painting and minor repairs is a matter which deserves greater recognition than it has generally received from engineers. European bridge builders have paid some attention to such features in a few instances, and in constructing the great arch bridge at Muengsten, Germany, which is described elsewhere in this issue, an unusually elaborate system of traveling stagings for reaching all parts of the metal work were designed and built by the engineers, but in America we cannot recall a similar structure where such devices have formed a part of the original work. This fact is all the more noticeable, because of the number of really large bridges which we have in this country where suitably designed inspection stagings or platforms could have been constructed at a very small cost, compared with the saving which they would have effected in future inspection and repairs. No engineer need to be told that it does not matter how well a bridge may have been designed and constructed in the beginning, it has to be inspected and minor repairs made frequently thereafter, and it must be periodically painted as long as it is in service. In nine cases out of ten, moreover, it depends upon the ease with which access can be obtained to the metal work which needs these attentions whether care is given to it at once, and when it will result in the greatest benefit, or whether it is deferred until the conditions are such that the work cannot be postponed any longer. It is in some respects one of the most creditable features of the Muensten bridge that every member of the whole superstructure, including the great arch span, can be easily reached by the engineers or inspectors who may for any reason desire to examine it.

An interesting interview with Admiral Sampson upon the war appears in the Boston "Journal" for Aug. 21. As Admiral Sampson was formerly Chief of the Bureau of Ordnance in the U. S. Navy Department, and is a widely acknowledged authority upon all that pertains to gunnery and explosives, his opinions as here expressed are worthy of the fullest consideration. In the first place he says that this war has taught many things to naval experts throughout the world; and one of the chief of these is the absolute necessity of making warships fireproof. He would not stop at the fireproofing of wood, but recommends that ships should be built practically without wood at all. As to torpedo boats, he warns the people who believe that boats of this type have been shown to be practically useless in naval warfare, that torpedo boats have never had a really fair test in this war. Those in use have been faulty in construction and equipment; and, as a rule, necessary qualities have been sacrificed to speed until they are mere egg-shells. Admiral Sampson contends that torpedo boats have their legitimate uses, but they should be made stronger, and there is no good reason why they should exceed a speed of 25 knots. In regard to the contention that 8-in. and rapid fire guns did most of the execution at Santiago and Manila, it is pointed out that the Spanish fleet at Manila was lightly armored; and at Santiago, the lightly armored parts were exposed to destruction, and it was these portions that were so badly wrecked. When it comes to piercing armor the large-caliber guns must be used, for the armor-piercing qualities of naval guns are almost exactly proportioned to their caliber; for example, an 8-in. gun will penetrate 8-in. armor, but a 12-in. projectile is required to penetrate 12-in. armor. Admiral Sampson says that smokeless powder should be at once supplied to our warships for several reasons. The most important of these is the resulting increase in velocity, from about 2,100 ft. per second for ordinary powder, to about 2,500 ft. for the smokeless powder. The smoke from the combustion of ordinary powder is also a great disadvantage, as it interferes with the sighting of neighboring guns, and consequently decreases the accuracy and rapidity of fire. One remarkable point made by Admiral Sampson is that out of 12,000 men engaged on the fleets there have been only 20 casualities throughout the war; a record unprecedented in any previous naval war. He ascribed practically all of the success of our ships to the fact that the United States navy is always upon a war footing; and ships are handled with as much exactness and discipline, and target practice is carried out with as much care and precision as if an enemy were constantly in sight. The same remark applies to the distribution of supplies and to the care of the well and the sick on board of our vessels. This generally excellent physical condition of our man-of-wars men is most remarkable, when it is remembered that some of the crews were not off their ships for more than six months.

Our attention has been called to an error regarding the names of the members of the Deep Waterways Commission, mentioned under "Notes in Detroit," in our issue of Aug. 18, 1898. Mr. Geo. W. Rafter, M. Am. Soc. C. E., is not a member of the Commission, but is its engineer in matters relating to the water supply of the canal, control of floods of tributary streams and allied matters. The third member of the Commission is Col. C. W. Raymond, M. Am. Soc. C. E., of the U. S. Engineer Corps.

THE REDUCTION IN RAILWAY TRANSPORTATION RATES IN THE UNITED STATES.

The decrease in railway passenger and freight rates in the United States since 1867 is made the subject of a special report recently published by the Division of Statistics of the Department of Agriculture. With a wealth of figures which we have never seen equalled regarding the subject the report traces the reduction in rates of transportation for the railway system of the country as a whole, and also for a large number of individual railways in widely separated geographical locations. In no case subsequent to 1868 do the former figures represent less than one-third of the total railway mileage of the country, so that they afford a fairly true index of general conditions. Their value for deduction is further increased by the fact that they have all been reduced to a gold basis, and are, therefore, susceptible of absolute comparison, which is not the case with many similar statistics where this reduction to a common basis has not been made.

To enable our readers to make these comparisons for themselves the accompanying table has been compiled from the detailed figures given in the report. This table, as will be seen, shows both the average freight rate per ton mile and the average passenger rate per passenger mile for each year from 1867 to 1896, inclusive. The decrease in freight rates per ton mile since 1867 has been fully 60 per cent.; that for passenger rates has been smaller, but except for about ten years previous to 1878 these charges have also shown a continual decline.

Table Showing Railway Rates in Cents per Ton-Mile, and Cents per Passenger-Mile, from 1867 to 1896, Inclusive.

Year.	Average cents per ton mile.	Revenue cents per pass. mile.	Year.	Average cents per ton mile.	Revenue cents per pass. mile.
1867	1.925	1.904	1882	1.102	2.391
1868	1.810	2.164	1883	1.204	2.402
1869	1.709	2.144	1884	1.136	2.323
1870	1.880	2.392	1885	1.011	2.216
1871	1.789	2.632	1886	0.909	2.142
1872	1.846	2.521	1887	0.984	2.245
1873	1.613	2.486	1888	0.941	2.108
1874	1.520	2.544	1889	0.922	2.105
1875	1.421	2.378	1890	0.941	2.107
1876	1.217	2.183	1891	0.895	2.142
1877	1.286	2.458	1892	0.898	2.126
1878	1.296	2.573	1893	0.878	2.108
1879	1.513	2.484	1894	0.860	1.986
1880	1.232	2.442	1895	0.839	2.040
1881	1.188	2.446	1896	0.806	2.019

While the means by which this steady reduction in the charges for freight service has been brought about are in a general way at least familiar to most engineers, they will bear being briefly restated. It is not always fully realized that, noteworthy as the reduction in the charges for carrying freight has been, it has been made possible only by a far more remarkable decrease brought about in the cost of carrying it. This has been due to a variety of economies resulting directly and indirectly from the general mechanical and commercial development of the country.

The mere growth of the country itself, offering a larger and more varied traffic and enabling the railways to utilize their facilities more fully, has obviously been a very important factor in bringing about greater economy in cost of transportation. A part of the gain has also been due to consolidation, by which connecting railways have been enabled to administer their affairs more cheaply. But the most notable part has been due to improved methods of handling the traffic itself, which have been made possible by the general introduction of more powerful locomotives and larger capacity cars, and by improving the roadbed, track and structures to withstand these increased speeds and loads.

With the increased capacity for doing business, railway managers arranged their rates to secure this business, without which it is needless to say the improvements in rolling stock and track would have amounted to very little. Gradually the fact came to be realized by the railways that for obtaining freight to fill their cars any rate was a paying rate when it would cover the difference between hauling them empty and hauling them full, provided, of course, that such rates developed additional business which could be obtained in no other way. The universal recognition and observance of this principle has been the largest single factor in making possible the extreme low freight rates of America as compared with other countries.

Interesting evidence of how this reduction of empty car mileage has acted is found by comparing some of the figures given in the report from which the above table was compiled. These figures show that the increase in the average number of tons of freight hauled one mile per mile run by freight trains has been from 81 tons in 1867 to 111 tons in 1877, 155 tons in 1887, and 199 tons in 1896. In other words, the increase in the efficiency of freight train service has made it possible to perform twice as much transportation per mile of line in 1896 as in 1867, without increasing train mileage.

These factors, which have had so much to do in reducing freight rates, have not been equally influential in reducing passenger rates. The reasons for this are obvious upon a little consideration. It must be remembered, however, that though it may appear from the table that the decrease in the charges for the transportation of

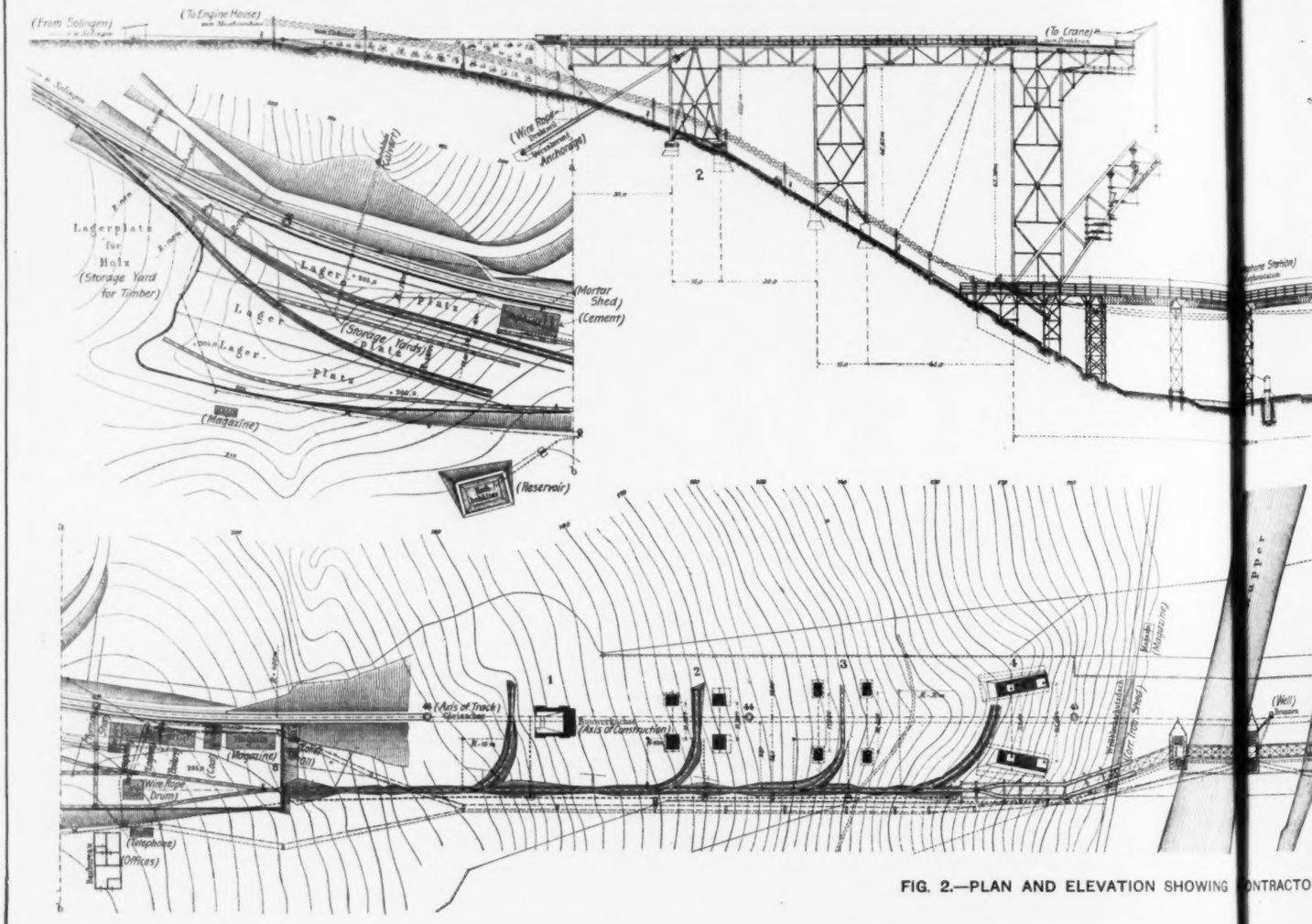


FIG. 2.—PLAN AND ELEVATION SHOWING CONTRACTO

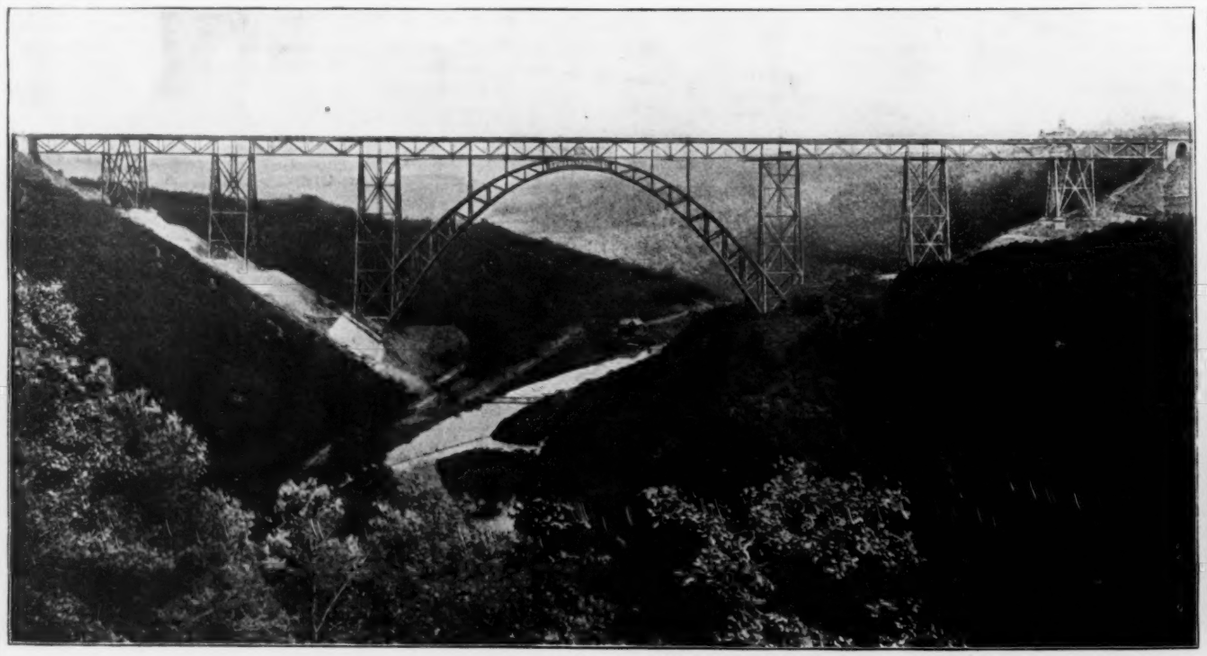
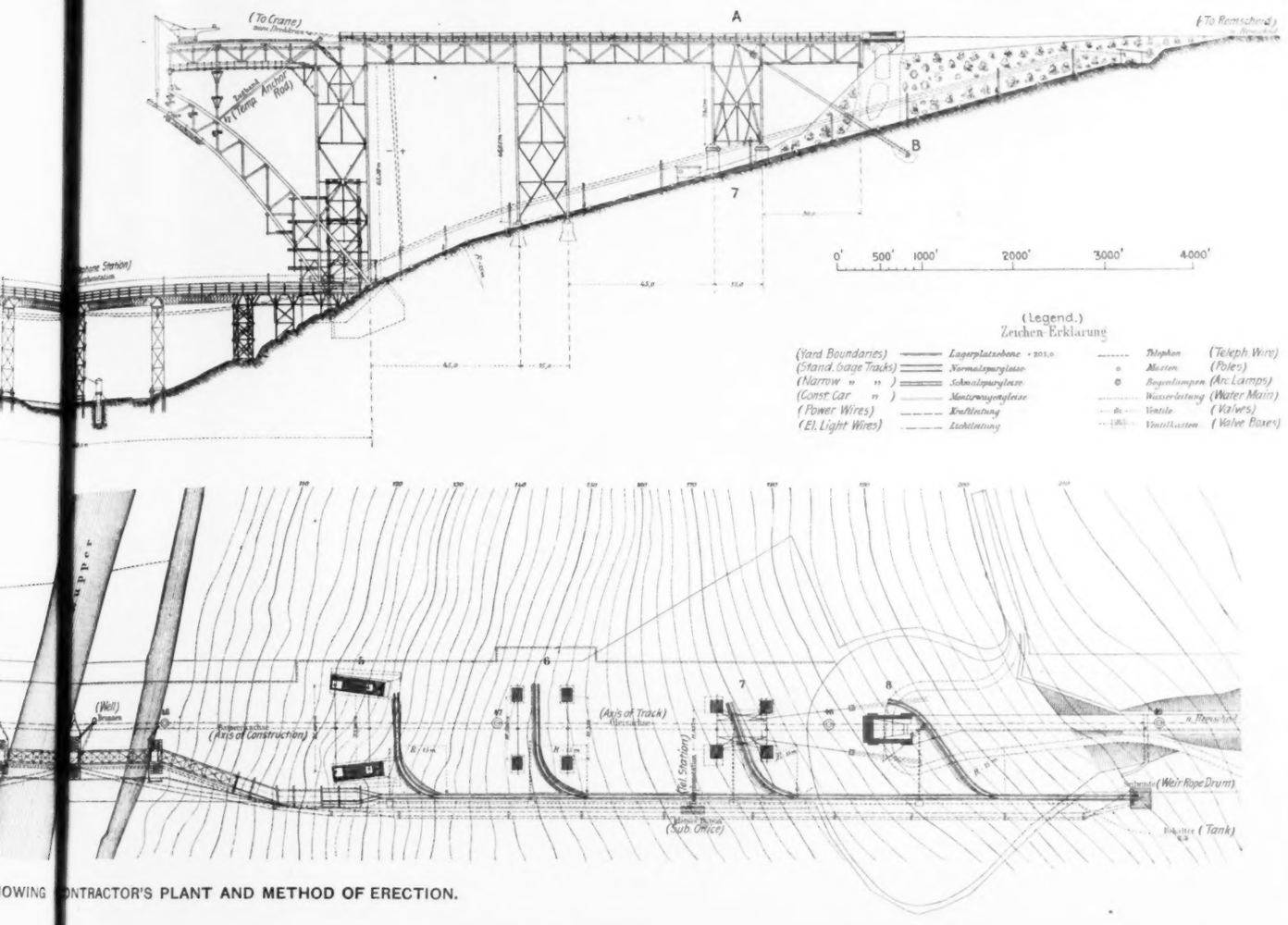
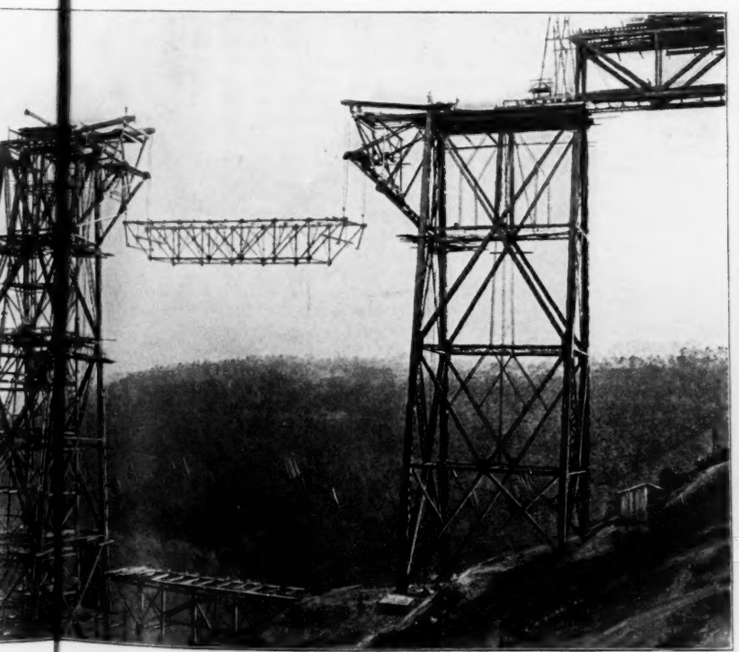


FIG. 1.—GENERAL VIEW OF BRIDGE AND THE VALLEY OF THE RIVER WUPPER.

FIG. 3.—VIEW SHOWING



HOWING CONTRACTOR'S PLANT AND METHOD OF ERECTION.



VIEW SHOWING ERECTION OF TEMPORARY STAGING TRUSS FOR VIADUCT SPANS.

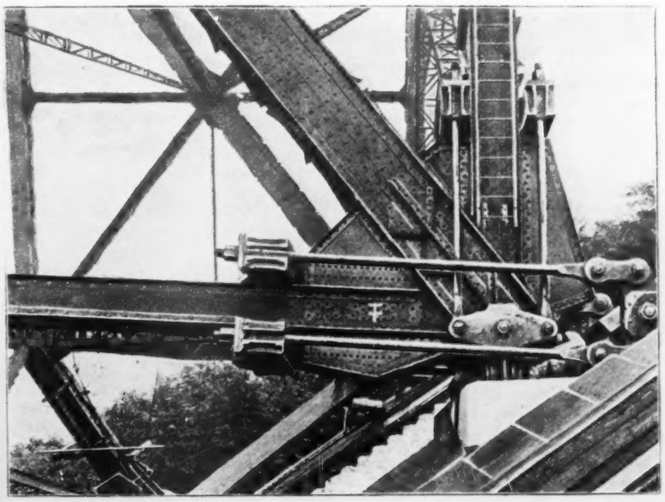


FIG. 4.—HYDRAULIC ADJUSTING DEVICE AT FEET OF UPPER CHORDS OF ARCH RIBS.

STEEL ARCH RAILWAY BRIDGE, MUENGSTEN, GERMANY.

Nuremberg Machine Works, Nuremberg, Germany, Designers and Contractors.

Mr. A. Rieppel, Engineering Director.

passengers has not been as great as that in the charges for freight service, the thing which the traveler purchases with the money paid as fare has varied in his favor in every important element except that of distance. The dollar with which a man purchases transportation on a modern fast passenger train, provided with air brakes and automatic couplers, running over stone-ballasted track laid with 80 and 100-lb. rails, and on a line equipped with block signals, purchases vastly more than a dollar paid 30 years ago, or, for that matter, even a decade ago. Studied in this light the apparently small decrease in passenger rates shown by the table assumes a different aspect.

So much for the methods by which the enormous reduction in railway rates in a single generation has been brought about. There is another phase of the subject, however, which is not brought out in the report, and which deserves to be considered. Statistics show that while the decrease in the cost of hauling freight and passengers has been coincident with the reduction in the rates charged, yet this decrease has been relatively smaller. On the Lake Shore & Michigan Southern Ry., for example, where these figures have been compiled on a uniform basis for the past 28 years, we find the following relative figures of income, cost and profit per ton mile, and per passenger mile at five-year periods:

	Freight service			Passenger service		
	Income, cts.	Cost, cts.	Profit, cts.	Income, cts.	Cost, cts.	Profit, cts.
1870	1.504	.932	.572	2.612	1.708	.904
1875	1.010	.737	.273	2.378	1.824	.554
1880	.750	.435	.315	2.135	1.086	1.049
1885	.553	.399	.154	2.058	1.250	.808
1890	.626	.458	.168	2.246	1.492	.754
1895	.561	.410	.151	2.139	1.368	.771
1897	.545	.356	.189	2.018	1.407	.611

Similar results are obtained when we analyze the figures published during the last few years in the statistical reports of the Interstate Commerce Commission covering the railways of the United States as a whole, showing that the particular figures given above are fairly typical of general conditions.

It is clear that the approximation of cost and income shown by such statements cannot contiuue indefinitely; the time must come when no margin will exist for a further reduction of freight rates particularly. Already, in fact, there are prominent railway managers who assert that this point has been reached, and that if railway rates are reduced further, the saving must come by reducing wages, or by practicing false economies in maintenance and renewals. Evidently the questions whether this statement is justified, and whether we can expect no further reduction in railway rates are worth some trouble to answer.

First of all, it is worth while to inquire whether the influences which have done so much to reduce the cost of railway transportation in the past have lost all their power for securing further economies. It will be admitted, we believe, that consolidation yet has something in store for us by further reducing expenses due to competition and the duplication of managements. But without going so far as this, it may be seriously questioned whether the efficiency of train service has been brought to nearly as high a standard as it is capable of reaching. Notwithstanding the great growth in the proportion of paying load hauled by freight trains, the average train load to-day is far below what is possible with modern equipment. Few engineers also will be ready to admit, we think, that no further economies are to be expected from the mechanical and engineering department of our railways.

No such revolution probably will ever again be wrought as that which followed the introduction of the steel rail, but a multitude of minor economies, the possibilities of which are being found out and improved each year, are gradually reducing the important items of expenses coming under the heads of maintenance of equipment and of maintenance of way and structures. In both these departments, notwithstanding all the improvements which have been made, the tools for conducting transportation are in many cases those designed for other conditions than they are now called upon to meet, and they are not, therefore, economical. No better evidence of this is needed than the constant progress being made by railways in replacing their old structures with new ones more durable and better fitted to perform economically the duties which devolve upon them.

The opportunity open to the traffic department to increase the efficiency of train service has already been mentioned. As the natural resources of the country are developed and its industrial life enlarges, offering a larger traffic, it will become easier to realize this opportunity, and it cannot be doubted, we think, that the future will show a material reduction in the figures of empty car mileage. But it must appear to anyone who studies the subject, we imagine, that more direct economies than this are still possible in conducting traffic. Take for illustration the single item of expense resulting from the employment of the present army of freight solicitors and the multiplication of outside agencies bidding for competitive traffic. Men well informed in railway traffic affairs freely acknowledge that, taken as a whole, these outside solicitors and agencies cost the railways more than they come to, and the crop of wastes and worse evils which has grown up about the practice is familiar to every student of railway traffic affairs.

The opportunities for further economies in the cost of hauling freight which have been mentioned, and others which will doubtless occur to the reader, indicate then that there is still room to reduce freight rates, low as they already are. Not the least important result of this conclusion is the force with which it exhibits the enormous and almost controlling factor which the steam railway has become in the transportation system of the United States. This is a matter which the advocates of ship canals have been slow to understand. As we have frequently asserted, it has yet to be shown that, when all the factors are fully considered, the margin between the cost of shipping freight by canal and shipping it by rail, even at the present rates, will pay for the cost of constructing such enormous waterways. But instead of a system which has reached its limits of economy in transportation in its present schedule of rates, these canals will have to compete with one which is evidently capable of still further reducing the costs of operation. This is a matter, however, which we have already considered at length, and with this brief reference it will not be alluded to further here.

A suggestive comparison which may be made in conclusion is the relation between the average yearly farm prices and railway rates during the period covered by the large table above. It appears from quite complete figures covering this point, which are given in the report, that for any series of years except the earliest, which may be selected, the decline in railway rates has been greater than the decline in the price of any of the leading staple crops. Wheat has declined in price 23 per cent. less than railway rates, and hay fully 12 per cent. less. The cost of shipping anthracite coal from the mines to tide water is to-day less than half what it was in 1869, but its price has decreased only about 10 per cent. in the same period. Similar results are obtained when the reduction in price of other commodities is compared with the decline in the rates charged by the railways for transporting them.

LETTERS TO THE EDITOR.

Notes of an Engineer in Colorado.

Colorado Springs.—This city has long stood in a class almost by itself, as being the largest in the West dedicated almost exclusively to the health and pleasure seeker. It is also the headquarters for most of the large mining enterprises of the Cripple Creek mining camp near here. The city is the chief point for side-trips to the several summer and pleasure resorts in this locality, of which Manitou is the most important, and also for visits to many of the most noted scenic attractions in the country. The streets and avenues are of generous width, 100 ft. and 140 ft. respectively, and the city extends over much territory. Notwithstanding this, however, the street car system seems to have been planned more with an eye to reaching the outside resorts than to the convenience of the citizens, and though 40 miles of track run through and out of the city the facilities, except for two or three of the principal streets, are quite poor. The line to and through Manitou take almost seven miles of track, the one to Cheyenne Canon, five miles, and the one to Roswell (a suburban railway town north of the city) about the same. No center poles for the trolley wires are allowed, which makes an excessive length of cross-wire between the pole lines near each curb.

Colorado Springs was one of the first cities to use street car sprinklers. The American Street Sprinkling Car Co., of Worcester, Mass., is operating one of its sprinklers here, the local street car company furnishing the power and the motorman. The car has an arm about 20 ft. in length, extending out horizontally, to sprinkle from. The car holds about 2,500 gallons, which makes a very heavy load on the rails. During the summer it is started early in the forenoon and is kept going all the day.

The city has about 30 miles of sewers, ranging in size from 6 ins. to 21 ins. The separate system is used. It was begun in 1888, and 1½ to 2 miles are being added yearly. The city, as stated in Engineering News of Feb. 23, 1893, adopted irrigation as a means of sewage purification, and the method worked well until the summer of 1894 when the unprecedented flood, due to the cloud-bursts in this vicinity, overran the sewer farm on the banks of the "Fountain Qui Bouille" or Fountain Creek, practically ruining it. Since then the sewage has been turned directly into the creek. This has renewed the old conflict with the landowners below the outlet, and the city is now considering the question of using the sewage again for irrigation, but on a larger scale and further removed from the city than before.

Colorado Springs has a water supply system with many interesting features, which was described at length and illustrated in Engineering News of Aug. 27, 1896. The most prominent part that lacked completion at that time was the Strickler Tunnel, intended to divert the water from the west slope to the east slope of Pike's Peak. I learned that this tunnel was not near completed, though 2½ years had elapsed since the letting of the contract. On the east end the rock was extremely hard and wholly without cleavage, requiring the rock to be literally honeycombed with drill holes, which even then blew out a very small quantity of material at a blast. The rock at the west end, while not nearly so adamantine, was seamy, which in addition to interfering with drilling developed large quantities of water. This had to be pumped out, as the grade here is descending. A large crevice filled with water, sand and gravel was encountered last November, and this led to making a detour from the center line to avoid it. Early this July the same crevice was struck some 12 or 15 ft. to one side of the center line, letting loose such a flood of water that for a while it was reported that the undertaking would have to be abandoned. The contractor is now making a wider detour than formerly. While it is tedious work to go through these crevices it is not at all impossible.

The tunnel is to be 6,242 ft. long, and it is hoped to complete it this year. While it is realized that the contract price—$100,000—will not nearly compensate the contractor, he is intent on saving his $50,000 bond. The electrical disturbances of the power machinery, difficulty of getting in supplies, etc., have done much to delay the work.

The Beaver Creek 16-inch main is also being paralleled this year. This supply main carries water from the Middle Beaver Creek to the top of Seven Lakes Divide. During the past two years the distribution system of the city has been steadily extended. About all of the public engineering works of Colorado Springs have been designed and carried out by Mr. H. I. Reid, who was city engineer for 14 years until April 18 of the present year. Mr. Reid is now conducting a private office as civil and consulting engineer, in the Gazette Building.

Colorado Springs is connected with Colorado City and Manitou on the west by two steam and one electric railways, and also by the main wagon road and a scenic driveway called the Boulevard. Colorado City—half-way to Manitou—was the first capital of the territory, but sadly fell behind all its competitors. On the building of the Colorado Midland Ry. to Leadville in 1887, however, the location of the shops here gave this town new life. And within the past two years a large chlorination plant for the reduction of the gold ores from Cripple Creek has been built and put in operation. These are just southwest of the city, and four miles from Colorado Springs. The present haul of the ores from Cripple Creek is 50 miles, but mostly down hill. Much is expected of the electric railroad now building to give a more direct connection between these two towns and the Cripple Creek district. The projected line runs up Bear Creek Canon from here directly toward the mining camp in a southwesterly direction. The haul to the reduction works will then be 25 to 30 miles, and the intention is to have several other plants built by the time the road is completed.

Pueblo.—Pueblo has been called the "Pittsburg of the West." The city now has a population of between 35,000 and 40,000. The smelters, steel works and railways are the three classes of industries that furnish the bulk of the employment to the workingmen, and there are about 75 smaller manufacturing institutions. About 5½ million dollars per year are disbursed in wages, on account of the industrial enterprises, or about $15,000 for every day in the year.

The three smelters, the Pueblo, Philadelphia and Colorado, had an output in 1897 of over $20,500,000 in value of gold, silver, copper and lead. This was an increase of over $5,000,000 on the product of 1896, which was the largest heretofore. Notwithstanding the great decrease in the prices of the three latter metals since 1892, before the

great slump in silver, the output of the smelters has nearly doubled since that year. The amount of gold turned out increased from 50,000 ozs. to 313,000 ozs., nearly entirely due to the discoveries at Cripple Creek. The Pueblo Smelting & Refining Co.'s smelter has the largest value of annual product of any in Colorado, and Pueblo for some time has held the position of the first smelting city in the world.

The Bessemer steel works of the Colorado Fuel & Iron Co. is the largest manufacturing plant in the state. When built in 1881 it was up-to-date in every respect, but most of the machinery became antiquated so that lately the plant has not been able to compete with those in the East having the modern improvements. In rolling rails, for instance, the handling has been almost entirely by hand. Early during the present year the plant was completely overhauled, and all of the old machinery except that in the nail mill and bolt factory was replaced by the latest improved. The rail mill, the plate mill and the structural steel mill have now the automatic mechanical devices for carrying the steel through from one set of rolls to the next without handling by hand. The rail mill has a maximum capacity of 1,200 tons daily. The rollers are of the interchangeable pattern and can be so adjusted as to handle structural iron when the demand for rails is not large enough.

It is recognized that the manufacture of structural and merchant iron and steel has become more and more the leading industry for rolling mills. About $450,000 were spent in these improvements. The whole plant will employ 2,500 men when all departments are running. In the mill 50,000-lb. and 20,000-lb. Shaw electric cranes are now used, where formerly only jib cranes were employed. For work in the yards there is a heavy track crane built by the Industrial Works of Bay City, Mich.

During 1897 the production of the works, in round numbers in pounds, was as follows: Merchant iron, 38,000,000; spikes, 4,300,000; bolts and nuts, 3,400,000; cast-iron pipe, 11,000,000; castings, 1,600,000. These were large increases over 1896, particularly in pipe. The pipe foundry does not run constantly like the others. It was idle for two months early in 1897, and for several months during the present year. The steel works supply material directly that is used over much of the West, and their product worked into forms for mining mill plants finds its way all over the globe.

The Colorado Fuel & Iron Co. is the largest of the kind in the West. It owns and operates many mines of coal and iron and numerous coke ovens in southern Colorado and New Mexico. A force of 7,000 men is employed. During 1897 the product of the mines and coke ovens was $4,000,000, and of the steel works $2,000,000 more; a total of $6,000,000. Of this about 84% was distributed as operating expenses. As stated before, the company produces its own iron and steel for the Bessemer works. The general headquarters of the company are at Denver.

Pueblo has some municipal works of considerable interest. The Arkansas River runs through the center of the city from east to west, thus dividing it into North and South Pueblo. This river is subject at times to tremendous floods, some of which have overflowed the business and manufacturing districts along the bottom lands and have done much damage. Large sums of money have been spent by the city in constructing earth and slag levees and masonry walls for confining the waters within proper channels. About $50,000 was spent on this work in 1897, and $50,000 more is being spent the present year. The official width of the river through the city is 152 ft. The large amount of slag available at the smelters here allows of its being used very cheaply for rip-rapping the earth embankments. This substance, as it comes from the slag pots in a hemispherical form, allows of being broken up into shapes that make an ideal material for steep rip-rapping, the pieces being laid in snugly and with the smooth surface next to the water. Where stone masonry is used the walls are vertical and on the line of the established river channel. At three of the principal streets the river is spanned by "triple triangular" truss bridges, a very unusual type in the West. Two of these are made wide enough to include street car tracks. All are single span. There are three large viaducts crossing the numerous railroad tracks along the low lands, one of 1,050 ft. length and two of nearly 400 ft. length each.

Pueblo's sewer system, as originally planned, was the Waring, but it has been added to by different city engineers and changed a good deal. The city has a very fair electric street car system that reaches the more important parts of the city and suburbs. The return current is conducted through a continuous wire laid between the rails. No paving has been done by the city as yet. The railways have a fine union depot in South Pueblo, completed in 1890, and some of them also have separate depots on the North side.

Florence.—Florence is the center of the most important oil producing region in the West. All the illuminating oil for Colorado, Wyoming, Montana, Utah and New Mexico (except for the east part of Montana and southeast part of New Mexico) is produced here. The Continental Oil Co., of Denver, a branch of the Standard Oil Co., supplies this oil, buying it from the refineries at Florence. There are over a half-dozen companies around Florence that produce oil, but it all goes to two large refining companies here. The production of the wells for 1897 was about 2,000 bbls. per day, while the capacity is 3,500 to 4,000 bbls. In refining, about 33% to 35% of the crude oil is obtained as refined petroleum. There is a great demand for the fuel oil which is a residue from the distillation. In the past most of this has been shipped, but during the last year there has been a great demand for it by the several gold reduction works here, for roasting the Cripple Creek ores in the treatment by cyanide, chlorination and smelting processes; consequently much less fuel oil is now available for shipment. Lubricating oils, axle grease, etc., are other oil products.

The Florence oil fields were first opened up in 1885, and since then drilling has gone steadily on. The wells usually run from 1,500 to 3,000 ft. deep, and the oil has to be pumped from 1,500 to 2,300 ft. An 8-in. casing is first put down (generally to bed-rock), then a 5⅝-in. one, then a 4¼-in. one, and finally a 2-in. one, all inside of one another. The oil rises in and is pumped from the 2-in. pipe, and the gas rises between it and the 4¼-in. pipe. Gas is obtained at many of the wells, and the pump rod for oil is then at one end of the walking beam of the engine, while the gas is led to a pump cylinder worked by a rod at the other end. The engines for pumps are usually of 15 HP., the pumps of 14-in. stroke and forcing oil at each stroke. The gas is forced through mains and used by numerous families for domestic purposes. No wells producing less than 10 bbls. per day are pumped here, and they run from that up to 200 bbls. Each well has a derrick of standard style, 74 ft. high. The residuum or fuel oil is used as fuel at both the wells and refineries.

Extensive coal beds are also found in the vicinity of Florence, and the coal camps to the southwest of town ship all the way from 700 cars in the summer to 1,800 cars per month in the winter time.

Cripple Creek Mining District.—I took a run from Florence up to this famous district, spending two days at it. The center of the district is but a few miles southwest of Pike's Peak and just behind the front range of the Rocky Mountains.

The history of Cripple Creek reads like a romance. In 1859, during the Pike's Peak excitement, prospectors passed through this region, but being totally unfamiliar with the occurrence of gold in compounds they little realized the stores of latent wealth they were leaving behind. In 1891 attention was drawn to the gold that was occasionally found in its free state in the gulches. At that time this region was but a "cow pasture," taken up by rangemen who roamed the hills with their herds of cattle. The first substantial results were obtained in Poverty Gulch, running through the present city of Cripple Creek. Outsiders were slow to believe that any great wealth could come out of this district. The people of Colorado Springs were the first to put faith in the value of the discoveries, and as a consequence more persons of this town have been rendered wealthy by this district than in all the rest of the country besides.

The output increased from 10,000 ozs. in 1891 to 100,000 ozs. in 1893, but the public at large was still skeptical as to the permanency of the district. In the latter year the closing down of the silver mines resulted in a large influx of skilled miners and prospectors into this region. By the end of the year public opinion was changing, and during the next year much capital from Denver and the East was invested. The first railway reached the district in 1894. During this year, however, occurred the great strike, which curtailed production and development, though the former reached 3¼ million dollars.

Geologically considered, the district consists of a granite floor upraised in the central portion above the general average level of the surrounding country, in the form of a very irregular basin. In this basin at the close of tertiary time a violent volcanic outburst took place, which formed the present surface of the ground and resulted in the mineralization of the district. The fissures in the ground were filled with siliceous waters carrying gold and other metals. So at the present time the gold is usually found in quartz veins surrounded by a porphyritic breccia. Owing to the action of the elements the ores have been oxidized to depths varying from 50 to 400 ft. below the surface. Below this zone the "live" ores are reached mostly in the forms of sylvanite and calaverite, chiefly the latter. The average composition of the ores shows the following proportions: Tellurium, 57.45%; gold, 40.6%; silver, 1.95%. The compound often has a steel-gray color, in appearance like a fracture. At the Independence Mine, where the vein is of very high value, it may be seen in bands of ¼-in. thickness spaced about 3 ins. apart. The number of mines shipping or in a position to ship at the close of 1897 has gradually increased to 250.

All the mines are worked or reached by means of shafts, and though several long tunnels are projected and under construction for the purpose of tapping the mines at greater depth (thereby serving for hauling out ore and for drainage) none has yet reached the depth to become a factor of much consequence. The production of the camp has increased year by year, until in 1897 it was over $12,000,000 or $1,000,000 per month. This placed Colorado in the front rank as a gold-producing state, her output for that year being between $21,000,000 and $22,000,000. California, which had before held the lead, contributed only $17,000,000 in 1897. Of the $61,500,000 produced in the United States, Cripple Creek is thus credited with one-fifth. At the present time the output is about $1,250,000 per month.

Of the leading mining companies here, the Portland stands at the head. It was incorporated March, 1894, with a nominal capital of $3,000,000 in $1 shares. The production increased from about $600,000 to over $2,100,000 in 1897. The Portland group comprises about 135 acres on Battle Mountain. The main working shaft is now down about 800 ft., has a hoisting engine of 600 HP., with drums of 14 ft. diam., and carrying a 6-in. flat rope cable, and has double-decked cages. The engine can hoist at the rate of 1,000 ft. per minute. The company pays regular dividends of 1% per month on the par value of the stock.

The Independence Mine, situated on the same mountain, is owned by W. S. Stratton, the eccentric millionaire, and its returns are not made public. Its output has averaged over $1,000,000 for the past three years. The Victor Mine is the oldest of the large producers, and its product has averaged nearly $500,000 the past three years. The average value per ton of ore from 47 of the principal properties has varied from $30 up to $350, this latter being the average value of ore from the Orizaba Mine, from which 333 tons have been shipped. The average value of milling ore at present is $25 to $30 per ton, of smelting ore (which is shipped much farther than the last) is $75 to $90. About one-third of all the ore is sent to the smelters.

During the early days of the camp a great mistake was made in assuming the ores to be free milling, and a number of stamp mills were erected which were found to save only a portion of the value in the ores. Some of these, however, are still run to treat ores of too low a grade to justify treating by any other process. But the chlorination and cyanide processes are now used nearly entirely for all ores not rich enough to send to smelters.

The first named process is more regular and adapted to a larger variety of ores than the second, but is more expensive. In cyanidization, as well as in chlorination, roasting is used on the Cripple Creek ores before leaching, except for the oxidized ores near the surface. For the sulphide and telluride ores roasting is necessary. Ores of whatever kind have to be roasted in the chlorination process. The chloride of lime and the sulphuric acid required in the chlorination process are much more expensive than cyanide of potassium, and the process also requires lead-lined vessels. The chemistry of the cyanide process is more complicated, however. For treating the Cripple Creek ores there are at present 9 reduction plants in operation, five using the cyanide and four the chlorination process. Five of these plants are at Florence and vicinity, one at Colorado City, one at Gillette, and the other two in the heart of the camp. The Metallic Extraction Co.'s cyanide plant, near Florence, has a capacity of 400 tons per day.

At Colorado City is the great chlorination plant of the Colorado-Philadelphia Reduction Co. Over a dozen buildings contain the machinery for the reduction of the ores, and the capacity is 250 tons per day. The process here is as follows: After being finely pulverized at the roll house, the ores are conveyed to the roasting department, 90 × 160 ft., where they are passed through two immense Ropp roasting furnaces, each with a capacity of 150 tons per day. From here they pass to the cooling room and thence to the chlorination department or barrel house, 68 × 150 ft. Here are 10 revolving barrels, each 6 ft. in diam. by 14 ft. long, of iron lined with lead, and with a capacity of 10 tons to each charge or 30 tons per day. In these the ores are chlorinated through the affinity that gold has for chlorine gas, the gold being extracted and converted into a chloride of gold solution. In this form it passes through a series of sand filters, from which the liquor passes into the eight immense tanks of the settling and precipitating departments, where any remaining slimes are settled. The clear liquor is then decanted into six precipitating vats below, where the gold is precipitated by the use of sulphureted hydrogen of gas, producing gold sulphide. This is pressed and dried and is then ready for melting in the crucible furnaces. From these the gold bullion—950 fine—is shipped for refining at the government assay offices.

The growth in population of the Cripple Creek district has kept pace with the mining development, and as a result a community numbering over 40,000 souls is now included within its bounds, where a few years ago less than 100 persons (all males) were to be found. The city of Cripple Creek—the metropolis of the district—contains between 15,000 and 20,000 people. In April, 1896, nearly the whole of the city was destroyed by two fires that rendered 15,000 people homeless. It has since been rebuilt, and the shacks so characteristic of a new mining camp replaced by substantial buildings.

The city has an excellent water-works supply. The water is obtained from Pike's Peak and conveyed through an 8-in. pipe line for 5 miles to a reservoir above town, which gives about 80 lbs. pressure. The distribution system consists of 8-in., 6-in. and 4-in. pipe. The works were built by and owned by the Michigan Pipe Co., of Bay City, Mich., who used their bored log pipe (wrapped spirally with flat bands) of the Wyckoff pattern. Iron is used only at T's, etc. The pipe was made at their factory. After being bored, it was dipped in coal tar, then banded, then dipped again and rolled in sawdust, which last protects the tar and allows it to be handled. This pipe is well suited for this country on account of rock being so near the surface, as it can be laid in a much shallower trench than iron pipe as regards freezing. It came in

lengths of about 10 ft. Water rates are reasonable, the charges for a six-room house being only $22 per year.

The other principal town of the district is Victor, which, though only four years old, has a population of 8,000 to 10,000. This is more nearly a typical mining town than Cripple Creek, most of the large mines (including the Portland and Independence) being located quite near by.

Power for operating the mines has become quite an item of expense in the Cripple Creek district. All coal has to be hauled in, and there has been presented the interesting problem of whether it would be cheaper to (1) bring fuel in from the coal camps, 25 or 30 miles off, and 4,000 to 5,000 ft. lower, or (2) to generate electricity right where the coal is produced and transmit it for power purposes to the mining camp. One large mining corporation has decided on the former, and is building a plant of its own at Goldfield—about a mile from Victor. It will have three 750-HP. steam engines. The Colorado Electric Power Co. believes there is money in the latter method, and it has lately completed a plant for a 26-mile transmission from Canon City to the center of the camp.

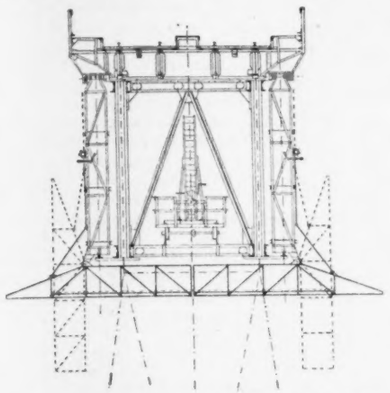


Fig. 5.—Traveling Inspection Platforms for Truss Spans; Muengsten Bridge.

Canon City is eight miles west of Florence, at the mouth of the Canon of the Arkansas River, and adjoining the famous Canon coal fields. Here on the river bank is the power house plant. The main building is 100 × 106 ft., and the converter building 27 × 72 ft. The principal machinery consists of three Hamilton-Corliss engines of cross-compound type; three three-phase 470-K-W. generators and four converters. All electrical machinery is Westinghouse make. Power is furnished by four 300-HP. Heine boilers. Room is left for a duplicate plant to be erected at the west end of the present buildings, when needed. Two shifts of ten men each are required to operate the plant. The direct distance by the transmission line to distributing station No. 1 (on the south slope of Bull Hill and between Victor and Cripple Creek) is 26 miles. The voltage is reduced here and lines are run to the different consumers.

An electric railroad called the Canyon City & Cripple Creek Electric Ry. has long been projected to connect the two places by a line much shorter than possible with a steam road, but it does not seem to have made much progress yet.

Resuming the journey to Leadville, Canon City (already noted) is first passed. The state penitentiary is located here. Several years ago an attempt was made by the state to utilize the labor of the convicts here in the construction of a large irrigation canal, called State Canal No. 1. A line was located, tapping Arkansas River within the mouth of the canon and running east as far as Pueblo. A large amount of work was done and a great expense incurred in outfitting the convicts, transporting them to and from the work and in guarding them. But finally a halt was called, as it was claimed that there would be no unappropriated water left for the canal even if built. A committee of the Tenth General Assembly was appointed to investigate and report as to the advisability of continuing work, which made a very able report advising abandonment of the project. This was done, and the only evidence now left of the work are the numerous tunnels and cuts in the rocky side of the canon near the town. W. P. H.

Salt Lake City, Utah, Aug. 1, 1898.

GRAVEL ROADS aggregating 40 miles in length are being built in Lake county, Ind. The excavation and grading is done by scrapers and then a bed of furnace slag is laid and covered with a top dressing of gravel, making a total thickness of 11 ins. at the middle. Formerly a 12-in. bed of gravel was used, but the slag costs only about half as much and makes a better foundation. The railways are assessed for taxes for this work, and in some townships pay 75% of the cost of the work, which may account in part for the people's desire for good roads. Mr. John Halloran, of Hobart, Ind., is the contractor for the work.

DOUBLE TRACK STEEL ARCH RAILWAY BRIDGE, MUENGSTEN, GERMANY.

(With double-page plate.)

The Muengsten Bridge, some of the principal features of which we illustrate on our double-page plate this week, was built to avoid a long detour in the line of railway connecting the towns of Solingen and Remscheid, lying on opposite sides of the deep gorge of the River Wupper, in Prussia. At the point where the bridge crosses it, this gorge is about 350 ft. deep, with sides inclined from 18° to 47° to the horizontal, and the parabolic arch springs from points on the opposite banks about 590 ft. apart. The stream itself is of small size, and offered little obstruction to erection.

Plans were submitted by four different engineering firms for the bridge, but the one finally adopted was that of the Nuremberg Machine Works, Ltd., Mr. A. Rieppel, Engineering Director. From a description by Mr. Rieppel in "Zeitschrift des Vereines Deutscher Ingenieure," Mr. O. J. Marstrand has abstracted the following information relating to the design and erection of the bridge. The accompanying illustrations have also been reproduced from the columns of the same publication.

The bridge, Fig. 1, is designed for two tracks and consists of a parabolic arch spanning the center opening and flanked on each side by steel viaduct approaches. The span of the arch c. to c. of abutments is 170 m. (357.8 ft.). On the Remscheid side the viaduct consists of three trestle towers, carrying one 30-m. (98.4 ft.) and two 45-m. (147.6 ft.) truss spans, and on the Solingen side of the same number of towers carrying two 30-m. and one 45-m. spans. The dimension of the tops of the towers in the line of the axis of the bridge is 15 m. (49.2 ft.). The total length of the bridge is 465 m. (1,525 ft.). Over the center span the continuation of the viaduct truss is carried by verticals to the arch proper below, spaced 30 m. and 15 m. apart, and by the crown of the arch itself.

The parabolic arch ribs have a web system of vertical and diagonal members forming a rib 4 m. (13.1 ft.) deep c. to c. of chords at the crown and 12.206 m. (40.05 ft.) deep at the abutments. The distance between the verticals or the panel length is 7.5 m. (24.6 ft.) The arch ribs are inclined inward 1 to 7 to the vertical, so that they are 5.0 m. (16.4 ft.) apart c. to c. at the crown; 25.685 m. (84.27 ft.) apart at the feet of the inside ribs, and 23.681 m. (77.69 ft.) apart at the feet of the outside ribs. The lateral wind-bracing is attached to the lower ribs, while the wind-strains in the top ribs are resisted by transverse bracing between the verticals; in the end panels this bracing is carried to the base of both the upper and lower ribs.

The sides of all towers, in the line of the bridge, are inclined to the vertical 1 to 7, and are 5 m. (16.4 ft.) apart transversely at the top. The vertical sides are 15 m. (49.2 ft.) apart. Both sides are braced by horizontals and cross diagonals. At the feet of the towers, and in the planes of the abutments of the arch, no horizontal bracing is employed. Towers Nos. 2 and 7 are designed as anchorages; the top chords of the trusses, which are continuous through several spans, being firmly attached thereto. The posts over the arch rib lie in the same plane as the sides of the arch. They are braced transversely, and are capable of transmitting lateral forces from the bridge above through the system of wind-bracing just described.

The viaduct spans, 15, 30 and 40 m. long, have vertical trusses 6.0 m. (19.7 ft.) deep and 5 m (16.4 ft.) apart. They are divided into panels 7.5 m. (24.6 ft.) long by a single system of triangulation. The principal horizontal bracing is between the top chords, and is independent of the roadway construction. In the 30-m. and 45-m. spans the lower chords are, however, also braced horizontally. At the end panels the wind-strains are carried from the top chord to the towers by transverse bracing.

The posts carrying the trusses over the arch are so connected to the bottom chord of the bridge that it is free to move and that no uncertain strains may be transmitted at these joints.

The trusses are made continuous over the approach bents on both sides, and over the arch. They rest on rollers on the top of the bents and at the abutments, but are rigidly connected at bents 2 and 7 and at the crown of the arch. Over the inside faces of bents 4 and 5 provision is made for the expansion of the top chord by separating the adjoining ends.

The floor system is so constructed of beams and stringers that the strains due to applying the train brakes and other longitudinal strains are transmitted through the stringer lying directly over the top chord to the latter, while the horizontal strains pass through stringers and diagonals into the floor beams at the panel points, and are thence carried into the chord system. All material in the superstructure is basic steel, the aggregate weight being about 5,100 t. (5,622 tons).

The methods adopted in erecting the steel work are of particular interest. In a general way this work may be divided into the erection of (1) the towers and the viaduct trusses, and (2) the arch ribs and the trusses carried by them.

Previous to beginning erection the contractors built a very extensive plant for carrying on the work. On the Solingen side of the gorge, Fig. 2, was established a yard for storing material and for the various necessary shops and store houses, power plant, etc. From this yard a railway ran down into the gorge parallel with the bridge site. A similar railway extended up the opposite side of the gorge, and a temporary bridge spanned the river and bottom of the gorge between the two railways. Spur tracks from the railway lines handled material to the sites of the several abutments and tower foundations. These railways were operated by wire cables run by electric motors placed at the top of the gorge on each side, and getting their power from the central power plant. An electric lighting system, a telephone system, water supply pipes, etc., were constructed as shown by Fig. 2, which also explains the general method of erecting the superstructure.

To erect the viaduct towers a timber staging was carried up inside the steel work on which was

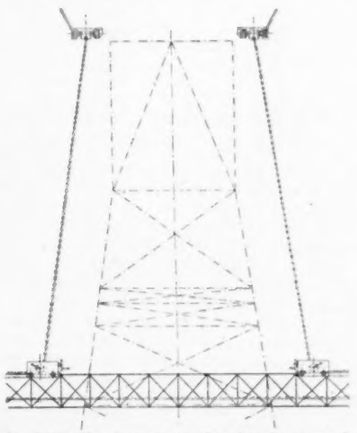


Fig. 6.—Traveling Inspection Staging for Arch Span; Muengsten Bridge.

mounted the necessary hoisting apparatus for handling the material. The viaduct spans at the extreme ends were erected by means of falseworks built up from the ground, and the intermediate spans by means of temporary staging trusses hung between the towers. These staging trusses or spans were first erected on the ground and then hoisted to the tops of the towers and hung from temporary cantilevers attached to the towers as shown by Fig. 3. Both the cantilevers and the staging span were made of steel, and upon them the permanent span was erected as it would be upon a falseworks resting on the ground. Altogether six spans of the viaduct were erected by this method.

The arch ribs and the truss spans supported by them were erected simultaneously. Referring to the elevation, Fig. 2, it will be seen that the extreme end towers were anchored by adjustable anchorages to the banks of the gorge. Between these two towers the trussed spans are continuous and serve as anchor rods. Therefore the truss span over the arch was built out as a cantilever as far as the first vertical. The arch ribs were

also built out as cantilevers to the same point, when the anchor rod A B was attached as shown by Fig. 2. These anchor rods on each side held the arched structure until the closure at the center relieved them. Material was handled by revolving cranes running on top of the trussed spans. The temporary stagings for riveting are indicated by Fig. 2. The final adjustment was made by means of hydraulic jacks placed at the crown of the arch and at the upper arch chord abutment connection. This adjusting device at the abutment is shown by Fig. 4. Hydraulic jacks were also arranged to tighten or loosen the anchor cables.

One other feature of the construction which deserves to be noticed is the rather elaborate permanent constructions to be used in the future inspection, repairing and painting of the bridge. The general nature of these devices is shown by Figs. 5 and 6, Fig. 5 showing the traveling staging and ladder for examining both the exterior and the interior of the truss spans supported by the arch and the towers, and Fig. 6 the corresponding device for examining the metal work of the arch proper. For the truss spans two forms of travelers are employed, one running inside the trusses and the other outside, each being intended to reach the corresponding part of the metal work. Two of the outside travelers are employed, each having a range of travel of one-half the length of the bridge, but the one inside traveler is operated the whole length of the trussed structure. For the arch proper the traveler is simply a foot bridge suspended by chains from a carriage running on the bridge tracks. By means of windlasses these chains are shortened or lengthened so as to bring the foot bridge at the proper height for easy access to the intrados of the arch at any point in its length.

Construction was begun on the superstructure of the bridge in the spring of 1895 and the structure was completed ready for the passage of trains on July 3, 1897. Under a test load, consisting of three locomotives followed by 40 loaded cars on each track, the arch span showed a maximum depression of 15.4 mm. (0.616-in.). The cost of the bridge was 6,147,830 fr. ($1,230,000).

THE HIGHEST CHIMNEY IN AMERICA.*

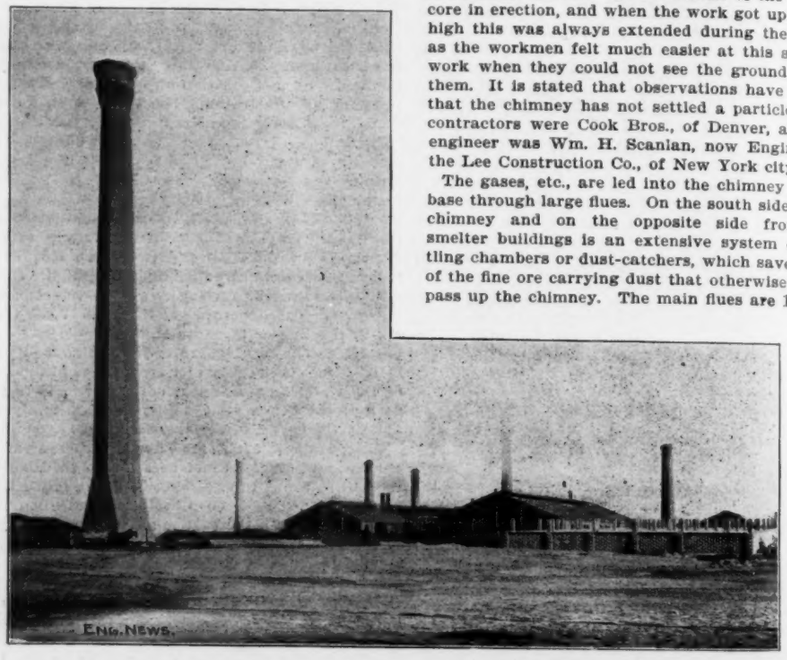
By W. P. Hardesty, C. E.

At Denver, Colo., is a brick chimney which is exceeded by but four in the world in height or size. This is the stack of the Omaha and Grant Smelter, which serves to carry away the poisonous fumes and gases generated in the process of smelting the precious ores at this extensive plant. The works here cover nearly 50 acres of ground, and before the panic of 1893 about 550 men were regularly employed. At present about 350 men are employed. After stacks of the ordinary size had been used for many years, it was decided that it would be better to erect one stack of great height, having sufficient size and draft to answer for all needs.

The present chimney has the following main dimensions: Height above the stone table at ground, 352 ft. 7 ins.; size at base, 33 ft. square; size at throat, 20 ft. in diameter; thickness of outer shell at base, 48½ ins.; at top, 13 ins.; thickness of core at base, 26 ins.; at top, 9 ins.; diameter flue, 16 ft.; foundation, 56 ft. square by 16 ft. deep.

In building, the ground was first excavated to the depth deemed sufficient, when about 2 ft. of water stood in the bottom. The material in the bottom was coarse sand. Then 8 ft. of cement concrete was put in, in which was placed a grillage of steel rails laid nearly together and crossing at right angles. These beams were used only in the masonry under and outside of the rings of masonry supporting the shell and core of the chimney. On top of the concrete was laid 8 ft. of brick work, stepped in about 1 in. at each course. On this was laid a stone footing 2 ft. thick, reaching above the ground level, and on this was built the chimney.

The shell or outer part of the chimney does not assume the regular octagon shape until 64 ft. high, the corner starting to batter off at about 25 ft. up. The exterior lines of the chimney are designed with an entastis or slight swelling, as shown. Two heavy systems of tie rods run through the chimney near its base in each direction. Where the main flue conveying the gases enters the chimney, an arch is sprung over the opening. The clearance between the flat sides of the shell and the outside of the core varies from over 2 ft. at the bottom to only 3 or 4 ins. at the top. At intervals along the sides are placed rollers to brace the core against the shell and to allow of the movement of the former in expansion. The expansion of the core when heated was estimated at about 4 ins. The draft to be expected under probable conditions as to temperature was taken to be equivalent to that caused by a pressure of 1-10 lb. per sq. ft.



THE HIGHEST CHIMNEY IN AMERICA.

Built for the Omaha & Grant Smelter, Denver, Colo. W. M. Scanlon, Architect; Cook Bros., Contractors.

The loads, etc., were taken as follows: Normal pressure on earth base, 3.2 tons per sq. ft.; total weight above foundation (on stone footing), 12,376,500 lbs.; pressure at base of shell, 148 lbs per sq. in.; at base of core, 160 lbs.; pressure on leeward side of base during a tornado, 295 lbs. per sq. in., and at windward side, 5 lbs., area exposed to wind pressure, 9,230 ft. Total wind pressure during a tornado, 369,200 lbs. Portland cement was used in the foundations, but above the larger part of the mortar was lime, and the proportion of lime was increased toward the top.

An average mixture was where a soft paste, made of about 2 bbls. of neat cement, would be added to and worked into a batch of lime mortar of about 6 times its volume, and then be hoisted to be used. All the bricks used were hard-pressed, from Golden, Colo. Push joints or shove joints were made in laying the brick, to secure the most compact work possible. At about 30 ft. below the top of the brick work, where the outer shell is but 13 ins. thick, the expansion for the cap begins. It swells out to a crown 5 ft. thick, and this was only done by using hoops and clamp rods built into the brick work to hold it together. The cast-iron cap weighs 22,000 lbs.

At intervals of 20 ft. in height, bands of 4-in. × ½-in. iron set vertically were built into the brickwork, four inches inside of the outer face.

An iron ladder is provided leading from the bottom of the space between the core and the shell to a trap door on top of the cast-iron cap.

The cast-iron cap has a lightning rod consisting of a ¾-in. galvanized wire rope securely fastened to it, the lower end of the conductor being fastened to an iron plate buried in the earth below the level of the ground water.

The following is a statement of the material actually used in the structure:

Brick		1,943,000
Lime, bushels		8,480
Portland cement.		Bbls.
1. In concrete		775
2. In stone work		26
3. In brick work		707
Total		1,508
Sand		2,331 cu. yds.
Railroad iron in concrete		48,960 lbs.
Beams under openings		2,574 "
Wrought-iron bands and rolls		23,180 "
C. I. plates and cap		56,474 "
Total		131,188 "

The chimney was built in 1892, the work being done in 120 days, and the total cost was $53,000. A scaffold was built up the interior of the flue or core in erection, and when the work got up pretty high this was always extended during the night, as the workmen felt much easier at this scaffold work when they could not see the ground below them. It is stated that observations have shown that the chimney has not settled a particle. The contractors were Cook Bros., of Denver, and the engineer was Wm. H. Scanlan, now Engineer of the Lee Construction Co., of New York city.

The gases, etc., are led into the chimney at the base through large flues. On the south side of the chimney and on the opposite side from the smelter buildings is an extensive system of settling chambers or dust-catchers, which save much of the fine ore carrying dust that otherwise would pass up the chimney. The main flues are 11 × 14 ft. There are altogether about two miles of flues and underground passages leading to the chimney from all parts of the plant, and the connections are such that all the smoke and gases from all the operations can be conducted to the one chimney.

*The four chimneys which exceed the Omaha and Grant chimney in height, according to Kent's "Pocket-Book for Mechanical Engineers," are at Hutte, Saxony, 460 ft.; two at Glasgow, Scotland, 454 and 435 ft.; and Bolton, England, 367½ ft.

STATISTICS OF RAILWAYS IN THE UNITED STATES FOR THE YEAR ENDING JUNE 30, 1898.

The statistician of the Interstate Commerce Commission, Prof. Henry C. Adams, has furnished to the press an advance abstract of the forthcoming tenth annual report of the commission, and from it we take the following figures of principal interest to our readers:

Mileage.—The total railway mileage in the United States on June 30, 1897, was 184,428.47 miles, there being an increase of 1,651.84 miles, or 0.91% during the year. In round numbers, Alabama shows an increase of 117 miles; Arkansas, 192 miles; California, 219 miles; Louisiana, 161 miles, and Michigan, 123 miles. The increase in mileage in the other states and territories in which an increase occurred was less than 100 miles. In a few states, as usual, a decrease in mileage is shown. The aggregate length of railway mileage, including all tracks, on June 30, 1897, was 243,444.41, the increase being 3,315.29 miles. The length of second track was 11,018.47 miles; of third track, 995.79 miles; of fourth track, 780.48 miles. The mileage of yard track and sidings amounted to 46,221.20 miles. Excepting yard track and sidings, about 32% of which are laid with iron rails, substantially 95% of the railway tracks in the country are laid with steel rails.

Equipment.—The total number of locomotives in service on June 30, 1897, was 35,986, the increase in number as compared with the preceding year being 36. Of this number, 10,017 were passenger locomotives; 20,398 freight lo-

comotives, and 5,102 switching locomotives. The number of locomotives not classified was 469. The total number of cars of all classes reported in service on the date named was 1,297,480. The corresponding number for the previous year was 169 greater. Of these cars, 33,626, or 623 more than for 1896, were assigned to the passenger service; 1,221,730 were assigned to freight service, indicating a decrease of 157 during the year; and 42,124 were assigned to the special service of the railway companies.

During the year ending June 30, 1897, the railways in the United States used 20 locomotives and 708 cars per 100 miles of line. Taking the United States as a whole, 48,861 passengers were carried and 1,223,614 passenger-miles accomplished per passenger locomotive, and there were 36,362 tons carried and 4,664,135 ton-miles accomplished per freight locomotive. All of these items show a decrease as compared with those of the preceding year. The number of passenger cars per 1,000,000 passengers carried during the year under consideration was 69, and the number of freight cars per 1,000,000 tons of freight carried was 1,647. It should be understood, however, that this average does not include such cars, mainly in the freight service, as are owned by private parties, for the use of which the railways paid during the year approximately $11,000,000. Including in the term equipment both locomotives and cars, it is found that the total equipment of railways on June 30, 1897, was 1,333,466. These figures are 133 less than on June 30, 1896.

Of this total number 525,286 were fitted with train brakes, the increase being 76,432; and 678,725 were fitted with automatic couplers, the increase in this case being 133,142. These increases are somewhat smaller than the corresponding increases for 1896. It should be noted, however, that the number representing the increase in equipment in that year was over 27,000. Further details as to equipment on June 30, 1897, show that the number of passenger locomotives fitted with train brakes was 9,890, or 83 more than the preceding year. The number of freight locomotives so fitted was 18,796, or 875 more than the preceding year. The number of switching locomotives fitted with train brakes was 3,666. The number of passenger locomotives fitted with automatic couplers was 4,687, the increase with respect to 1896 being 184. The number of freight locomotives fitted with automatic couplers was 4,192, the increase being 819. The number of switching locomotives fitted with such couplers was 741, or 147 more than for 1896. The number of passenger cars fitted with train brakes on June 30, 1897, was 33,078, and the number fitted with automatic couplers was 32,661, the increase in the one case being 665 and in the other 815. The number of cars in freight service fitted with train brakes was 453,688, or 74,630 more than on June 30 of the previous year. The number fitted with automatic couplers was 629,390, indicating an increase of 129,166. Of the total cars in service 492,559, on June 30, 1897, were fitted with train brakes, and 668,937 were fitted with automatic couplers, the increase for the year in the former case being 75,237; in the latter, 131,989.

Employees.—The number of men employed by the railways of the United States on June 30, 1897, as reported, was 823,476, or 449 men per 100 miles of line. The corresponding figures for the year ending June 30, 1896, were slightly larger. Regarding the year ending June 30, 1897, it appears that the aggregate amount of wages and salaries paid employees was $465,601,581. This amount represents 61.87% of the total operating expenses of railways, or $2,540 per mile of line. The total compensation for 1896 was $3,222,950 greater.

Capitalization and Valuation.—On June 30, 1897, the amount of railway capital outstanding was $10,635,008,074, which, assigned on a mileage basis, shows a capital of $59,620 per mile of line. The amount of capital stock was $5,364,642,255, of which $4,367,056,657 was common stock, and $997,585,598 preferred stock. The amount of funded debt was $5,270,365,819. The classification of funded debt shows that it consists of mortgage bonds, $4,539,911,595; miscellaneous obligations, $430,718,303; income bonds, $259,847,154, and equipment trust obligations, $39,888,767. The amount of capital stock paying no dividend was $3,761,092,277, or 70.10% of the total amount outstanding. The amount of funded debt, excluding equipment trust obligations, which paid no interest was $867,950,840. Of the stock paying dividends, 5.37% of the total stock outstanding paid from 1 to 4%, 6.53% outstanding paid from 4 to 5%, 5.99% outstanding from 5 to 6%, 3.58% outstanding from 6 to 7%, and 4.62% outstanding from 7 to 8%. The total amount of dividends was $87,110,599, which would be produced by an average rate of 5.43% on the amount of stock on which some dividend was declared. The amount of mortgage bonds paying no interest was $615,259,989, or 13.55%; of miscellaneous obligations, $37,345,879, or 8.67%, and income bonds, $215,344,972, or 82.87%. The amount of current liabilities outstanding on June 30, 1897, was $578,501,635, or $3,156 per mile of line.

Public Service.—The number of passengers carried during the year was 489,445,198, there being a decrease of 22,327,539 as compared with 1896. The number of passengers carried one mile during the year was 12,256,939,647, a decrease of 792,067,586 being shown in this item as compared with 1896. The number of passengers carried one mile per mile of line was 66,874, a decrease of 4,831. The number of tons of freight carried during the year was 741,705,946, 24,185,439 less than for 1896. The number of tons of freight carried one mile was 95,139,022,225, a decrease of 189,338,053. The number of tons of freight carried one mile per mile of line was 519,070, 4,753 less than for the preceding year.

Earnings and Expenses.—The gross earnings of the railways of the United States for the year ending June 30, 1897, as reported for an operated mileage of 183,284.25, were $1,122,089,773, a decrease of $28,079,603 for 1896. The expenses of operation for the year were $752,524,764. This amount is $20,464,280 smaller than for the year 1896, the operated mileage for that year being 181,982.64 miles. The operating expenses of 1897 were distributed as follows: Maintenance of way and structures, $159,434,403, decrease as compared with the preceding year, $910,547; maintenance of equipment, $122,762,358, decrease, $10,619,640; conducting transportation, $432,525,862, decrease, $9,691,720; general expenses, $36,481,269, increase, $397,984. Gross earnings per mile of line operated averaged $6,122; operating expenses, $4,106. These amounts are, respectively, $198 and $142 less than the averages for 1896.

Accidents.—The total number of casualties to persons on account of railway accidents for the year ending June 30, 1897, was 43,168. Of these casualties 6,437 resulted in death, and 36,731 in injuries of varying character. Of railway employees, 1,693 were killed and 27,667 were injured during the year. The casualties to employees resulting from coupling and uncoupling cars were, killed, 214; injured, 6,283. The corresponding figures for the year ending June 30, 1896, were 229 killed and 8,457 injured. The total number of passengers killed during the year under review was 222, injured 2,795. From summaries showing the ratio of casualties, it appears that 1 out of every 486 employees was killed and 1 out of every 30 employees was injured during the year. One passenger was killed for every 2,204,708 carried, and 1 injured for every 175,115 carried. Basing ratios upon the number of miles traveled, it appears that 55,211,440 passenger-miles were accomplished for each passenger killed, and 4,385,300 passenger-miles for each passenger injured.

HEAVY CONSOLIDATION LOCOMOTIVES FOR THE BURLINGTON & MISSOURI RIVER R. R.

One of the marked features of modern motive power equipment is the great increase in the size, weight and power of freight engines, in order to secure the economic advantages which result from an increase in the train loads hauled. We have already had occasion to illustrate and describe some of these large and powerful engines, and we are now able to give particulars of other engines which are illustrative of the present tendency towards heavy train loads.

The locomotives referred to are four consolidation engines, with 166,000 lbs. on the driving wheels, intended for regular freight train service on the Black Hills division of the Burlington & Missouri River R. R. (Burlington system), between Edgemont and Deadwood, So. Dak., a distance of 107 miles. The track has the standard gage of 4 ft. 8½ ins. The maximum grades are 2% against northbound traffic and 3% against southbound traffic. The minimum curvature is 16°, and most of the curves are under 10°, all having spiral transition curves, and being equated for the grades. Mr. T. E. Calvert, General Superintendent of the B. & M. R. R. R., informs us that the slow freight trains usually make the trip in ten hours, the load behind the tender being about 330 tons northbound and 200 tons southbound. The new engines are intended to haul 15 cars where the present engines haul 10 cars. As the weak point of the present engines is in their boilers, the new engines have boilers of specially large capacity. The following table gives the comparative dimensions of the old and new engines:

	Old engines.	New engines.
Driving wheels	3 ft. 8 ins.	4 ft. 4 ins.
Weight on driving wheels	101,820 lbs.	166,000 lbs.
Weight, total	118,310 "	181,200 "
Cylinders	20 × 24 ins.	22 × 28 ins.
Boiler pressure	160 lbs.	180 lbs.

The engine has a compact and powerful appearance, with the extreme simplicity of finish which is characteristic of modern locomotives. It has a Belpaire boiler of somewhat unusual design, the shell at the firebox having convex sides swelling to a width greater than that of the flat

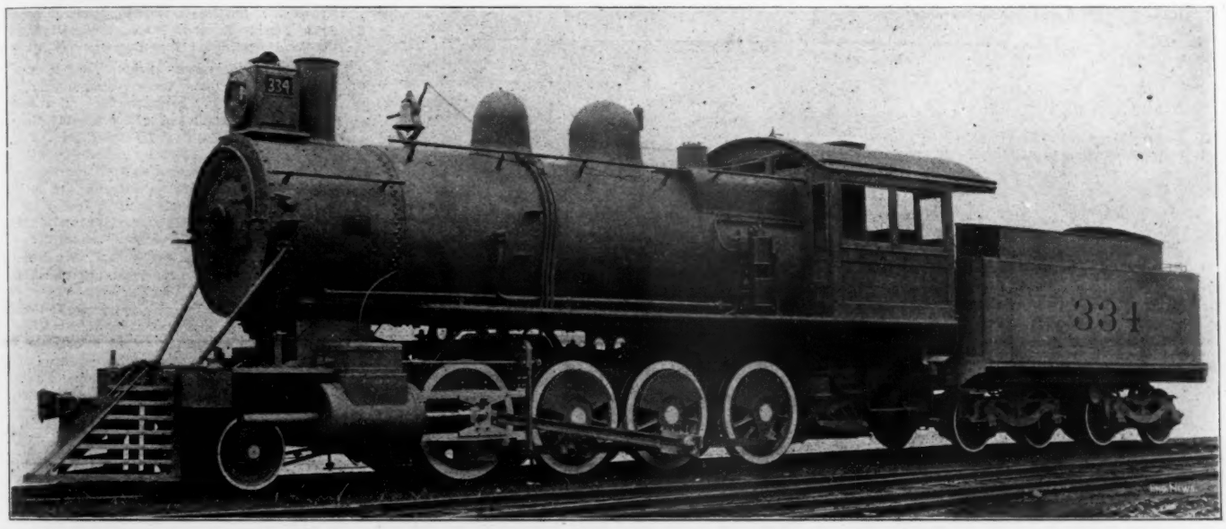


Fig. 1.—CONSOLIDATION FREIGHT LOCOMOTIVE; BURLINGTON & MISSOURI RIVER R. R.
Pittsburg Locomotive Works, Builders.

top of the boiler sheet, so that there is a peculiar reversed curve connection between the vertical sides of the flat boiler head and the convex sides of the shell. This is somewhat similar to the boilers of the class HH consolidation engines of the Pennsylvania R. R., but in general boilers of this type have a more symmetrical arrangement of the side and top plates of the shell. Another special feature is the use of a boiler jacket of cold-rolled pickled steel, painted black, instead of the planished iron jacket which has for so long been characteristic of American locomotives, but which is now gradually giving place to a more economical form of covering. The lagging is of asbestos.

The fuel used will be bituminous coal. The firebox has a brick arch, supported on studs, and has cast iron grates of the railway company's standard pattern. The dome and sandbox are on the boiler barrel, the former having the whistle attachment in the side, and the latter being fitted with the Leach air-jet sanding device. It has also a pneumatic blow-off cock and bell ringer. A special fitting on the boiler heads carries the safety valves. The smokestack is of the bootleg or tapering pattern, with its narrowest part just above the smoke-box.

The driving wheels have cast-iron centers, and all have flanged tires. This is a somewhat notable departure from regular practice, and will be observed with interest in view of the character of the line on which the engines are to run. It is

Heavy Consolidated Freight Locomotive; Burlington & Missouri River R. R.

Running Gear:	
Driving wheels, S; diameter	4 ft. 4 ins.
Truck wheels, 2; diameter	2 " 6 "
Tender wheels, 8; diameter	3 " 1 "
Driving wheel centers	Cast-iron.
Truck and tender wheels	Chilled cast-iron.
How are driving-wheel tires secured?	By shrinkage.
Engine truck, swing center; journals, drvg axles	9 × 10 ins.
Wheelbase.—Driving	15 ft. 0 ins.
Total engine	23 " 6 "
Engine and tender	53 " 2 "
Truck axle to leading driving axle, c. to c.	8 " 6 "
Wheels having blind tires	None.
Weight in Working Order:	
On driving wheels	166,000 lbs.
On truck wheels	15,200 "
Engine, total	181,200 "
Tender, empty ..35,000 lbs.; loaded	94,200 "
Water in tank	41,700 "
Coal on tender	17,500 "
Does counterbalance conform to M. M. Assoc. rules?	Yes.
Cylinders	22 × 28 ins.
Form of crosshead and guides	Alligator.
Connecting rod, length between centers	10 ft. ¾-in.
Slide rod	Strap and forked ends.
Valve Gear.—Type	Stephenson link.
Ports, steam..1¼ × 18⅝ ins.; Ports, exhaust..3 × 18⅝ ins.	
Eccentrics, throw	2½ "
Slide valves, style	Richardson balanced.
" maximum travel	5 ins.
" outside lap	¾-in.
Boiler.—Type	Belpaire.
Diameter, barrel, inside smallest ring	6 ft. 2 ins.
Barrel plates..⅝-in.; Smokebox tube-plate	½-in.
Horizontal and circumferential seams	Double riveted.
Joints	Butt, with inside and outside welt.
Rivets	⅞-in.
Height from rail to center line	8 ft. 9⅝ ins.
Length of smokebox, including extension	5 "11⅞ "
Spark arresting device	Netting, mesh 2 × 2 "
Injectors, two	"Monitor" and "Friedman."
Working steam pressure	180 lbs.

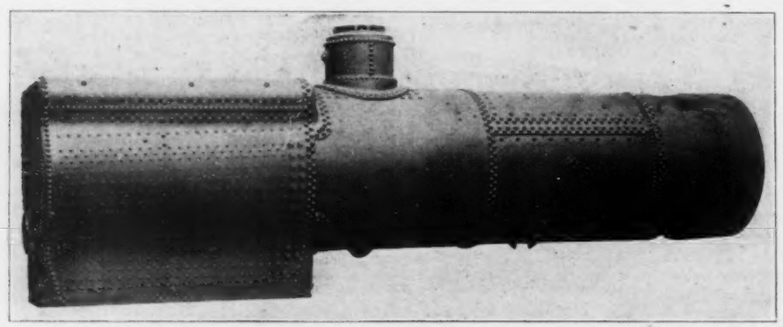


Fig. 2.—BELPAIRE BOILER FOR CONSOLIDATION LOCOMOTIVE; BURLINGTON & MISSOURI RIVER R. R.

more or less of an experiment. To partially overcome the crowding against the rail, the flanges of the forward and rear driving wheels are turned down 1-16-in. below the M. C. B. standard, making the flange 1 3-16 ins. instead of 1¼ ins. The second and third pairs of driving wheels have flanges of the standard dimensions. All the driving wheels are set ⅛-in. closer together than in regular practice, the distance between backs of wheels being 4 ft. 5¼ ins. instead of 4 ft. 5⅜ ins. The pistons are of cast steel, fitted with the Dunbar packing, and have 4-in. steel piston rods. The slide valves are of the Richardson balanced pattern.

The pilot is of wood, with a vertical projecting nose, reinforced by steel plates, and the point is supported by tie-rods from the bumper beam. Automatic M. C. B. coupler heads are fitted to the pilot and tender drawbars, and that of the latter has a swinging head and fixed knuckle. The tender is of the hopper type, built to the railway company's standards, and has semi-elliptic truck springs. The tank is 19 ft. long and 9 ft. 6 ins. wide, the length of tender frame being 32 ft. 3½ ins.

Fig. 1 is a general view of the engine, and Fig. 2 is a view of the boiler, showing the heavy character of its construction and the special features of the design.

The four engines were designed and built by the Pittsburg Locomotive Works, Pittsburg, Pa., under the general direction of Mr. G. W. Rhodes, Superintendent of Motive Power of the Chicago, Burlington & Quincy R. R., which system comprises the B. & M. R. R. R. Mr. D. Hawksworth is superintendent of motive power of the latter road.

The leading dimensions and particulars of these engines are as follows:

Forebox.—Type	Belpaire.
Length, inside	9 ft. 5¾ ins.
Width, inside, at top, 5 ft.; at bottom	3 " 4 "
Depth, front.5 ft. 11⅞ ins.; at back	5 " 8¾ "
Side plates	⅝-in.; back plates ⅝ in.
Crown plates	⅝-in.; tube plate ½-in.
Crown stays	Radial, 1⅛ ins.
Is firebrick arch used?	Yes.
Stay bolts (drilled) diameter, ⅞-in.; pitch	4 and 4½ ins.
Water spaces, width at front, back and sides	4 "
Tubes.—Number	202
Diameter, outside	2¼ ins.
Length over tube plates	14 ft. 6½ "
Heating Surface and Grate Area:	
Heating surface, tubes (interior area)	2,486.4 sq. ft.
" firebox,incldg brick arch t'bs	188.6 "
" total	2,675.0 "
Grate area	31.6 "
Miscellaneous:	
Exhaust nozzle, single, diameter	5, 5¼ and 5½ ins.
Exhaust nozzle, distance below center line of boiler	4 "
Smokestack, diameter at top 17 ins.; at base	16¼ "
" height above smokebox	3 ft.
" height of top above rail	15 "
Capacity of tender tank	5,000 gallons.
Capacity of coal space	17,500 lbs.
Brake fittings	Westinghouse-American.

ANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The 50th meeting of this Association was held in Boston during the week beginning Aug. 22. During the same week, or in the latter half of the week preceding, there were held meetings of several affiliated societies, as follows: American Forestry Association, Aug. 23 and 24; Geological Society of America, Aug. 23; American Chemical Society, Aug. 22 and 23; Society for the Promotion of Agricultural Science, Aug. 19 and 20; Association of Economic Entomologists, Aug. 19 and 20; American Mathematical Society, Aug. 19 and 20; Society for the Promotion of Engineering Education, Aug. 18, 19 and 20; American Folk-Lore Society, Aug. 25; National Geographic Society, Aug. 25; Botanical Society of America, Aug. 19 and 20; Conference of Astronomers and Physicists, Aug. 18 to 20.

The meeting of the American Association for the Advancement of Science was the largest it has ever held with three exceptions—Boston, 1880; Montreal, 1882, and Philadelphia, 1884. The meetings of 1883 and 1884 were enlarged by the presence of many members of the British Association. The Boston meeting of 1880 registered 998 members as present, and that of 1898 only 903. The evident decline in membership and in interest in the Association during the last 18 years is due to the growth of the affiliated societies of specialists, which have in most cases originated in the sections of the Association. By the scheme of having these societies meet at the same place and time each year they are practically the same as sections of the parent association. In fact some of these societies joined with the sections in holding their meetings. While the registered list of members present at the Boston meeting has been three times exceeded, there is no doubt that if the members of the affiliated societies who attended their several meetings but who are not members of the Association were counted, it would be found that in the week of Aug. 22-27 in Boston, there was the largest gathering of scientific men ever known in this country.

The meetings, both of the American Association and of the affiliated societies, were highly successful, both in the numbers of papers presented and in the attendance at the several sessions. Some idea of the vast amount of work done in the sections of the Association is given by the following list of the sections and the number of papers presented in each. Section A, Mathematics and Astronomy, 39 papers; B, Physics, 52; C, Chemistry; D, Mechanical Science and Engineering, 80; E, Geology and Geography, 27; F, Zoology, 35; G. Botany, 56; H, Anthropology, 55; I, Social and Economic Science, 29.

The following are abstracts of the most important papers presented in Section D.

A Combination Absorption and Transmission Dynamometer for Laboratory Purposes.

By John Joseph Flather, Minneapolis, Minn., Professor of Mechanical Engineering, University of Minnesota.

This paper describes some recent improvements in Prof. Flather's hydraulic transmission dynamometer, the most notable feature being the employment of a water-cooled pulley and a perforated rim which permits the use of a brake band that can be used for absorbing the power furnished to the machine. The fixed pulley which is ordinarily used to connect the dynamometer to the machine to be driven has internal flanges for carrying the cooling water and the rim is furnished with a number of brass bushings drilled through endwise, and provided with a regulating screw by which the amount of water admitted to the brake is readily controlled. The brake band is a three-ply cotton belt 7 ins. wide, connected through two sets of tension springs to the brake regulating screw.

The brake band may be quickly removed, thus converting the machine into a regular transmission dynamometer. In either case an automatic record is obtained on a roll of paper which is caused to pass with uniform motion under an indicator pencil that records variations of pressure.

In addition to the force curve traced by the indicator pencil the zero or datum line is traced by another pencil which is adjustable in position and may be located at pleasure on a line parallel with the axis of the shaft. Thus one is enabled to measure the total power required to run a given machine or any subdivided part of it. The two cylinders through which the driving power is transmitted are each 10 sq. ins. in area and are provided with bronze pistons actuated by plunger pins which may be located in either of two positions—the inner for ordinary work and the outer for extra heavy work, say when it is required to measure 20 HP., or when the speed of rotation is very slow. Springs of varying degrees of intensity may be used to transmit the pressure from shaft to indicator pencil. These springs are changed as in any ordinary indicator.

The work of friction of the plunger in the cylinder is practically eliminated, since the combined area of the plungers is so much greater than in the indicator piston; and since the indicator motion multiplies the distance moved by the indicator piston five times, it will be seen that the motion of the plungers is exceedingly small. The more recent machines are provided with adjustable casters which permit the weight of the dynamometer to be carried by wheels or to rest firmly on the floor, as desired.

High Speed Influence Machines.

By Charles F. Warner, Cambridge, Mass.

The causes of the electro-motive force in influence machines, their reversals and certain other peculiarities are not known; hence improvements have been effected by purely experimental means. A reference to some properties of earlier machines is made and to recent improvements under patents by Waite, Myers and Rose, Holopeter and Elihu Thompson.

The special improvements which it is the main purpose of this paper to recount are effected by special insulation, improved contacts, careful balancing of revolving parts, and peculiar driving mechanism. The inconvenience from reversals is largely overcome by a newly devised commutator. In order to provide for discharges of great frequency, such as are required, for example, to produce the Rontgen rays effectively, the principal aim has been to secure high speed with ease and safety. Two forms have resulted. One, designed for compactness, has ball bearings. The other of larger dimensions has gear metal bearings. The speed attained exceeds 4,000 revolutions per minute,

which is the highest rate the author has been able to find recorded for influence machines. The regulating discharges are of great frequency and, for certain purposes, are remarkably efficient.

Instruments and Methods of Hydrographic Measurements Used by the United States Geological Survey.
By F. H. Newell.

By the organic law creating the Geological Survey, the Director is charged with the duty of the classification of the public lands and examination of the geological structure, mineral resources and products of the national domain. Under this general law extensive surveys have been carried on through nearly 19 years. It has been found that throughout a great part of the country the most valuable of the natural resources is the water. Especially is this true of the western half of the United States where all land values rest upon questions of water supply. The subject of the hydrography of the country was thus early forced upon the attention of the topographers and geologists of the survey and a large amount of information collected as incidental to other work. In 1888 the division of hydrography was created, systematizing the observations and data bearing upon the water resources, and examinations were begun of the distribution and fluctuations of waters above and under ground. The methods employed have resulted from many years of experience and are of such a character as to obtain the desired information with an accuracy consistent with a fair degree of scientific value and yet with full consideration of the expenditure available.

In the measurement of various streams, especially of the larger rivers, it has been found desirable to seek a locality where the bed and banks are fairly stable and the velocity of the water moderate. The width and depth have been obtained by direct measurements and the rate of flow determined at various points in the cross-section by means of various forms of current meters. Computations based upon the slope and other factors have been made in a few instances but mainly as a matter of curiosity to note the possible accordance with the results of detailed current meter measurements. Estimates of the flow over weirs or dams have been had occasionally, but the uncertainties involved in the leakage and discharge through gates, water wheels, etc., have been so great that little reliance has been placed upon these computations. The great bulk of the data has been derived from computations based upon the direct measurement of velocities throughout the cross-section of a stream when standing at various heights.

At the selected points, daily observations of the height of water are made, and by means of these and the occasional discharge measurements, computations are made of the daily discharge. Graphic diagrams are then constructed and averages drawn for the month, the results being expressed in cubic feet per second or in depth in inches of the run-off from the entire drainage basin. The diagrams afford a means of comparing the regimen of one river with another and of noting fluctuations day by day or year by year.

Evaporation and Seepage from Reservoirs and Rivers.
By Prof. L. G. Carpenter, Fort Collins, Colo.

From two seasons' measurements on a series of reservoirs in Colorado, the author determines that in those cases the loss from seepage is much less than from evaporation, amounting to about 2 ft. in depth per annum. Eleven years' determination of evaporation shows the loss from that source to be 41 ins. from his standard tank. From the reservoirs under observation, several years' record indicates a loss of about 60 ins. from evaporation.

(This is printed as Bulletin No. 45, Colo. Agr'l Experiment Station.)

The author reports also the results of a series of measurements made on a number of rivers in Colorado. Two measurements were made on the Rio Grande del Norte over a stretch of 80 miles; fourteen measurements on the Cache a la Poudre for 40 miles; one on the Arkansas for 200 miles; one on 40 miles of the Big Thompson; seven on the South Platte for 150 miles; a distance of over 2,000 miles gone over in detail, and on which all water taken out by ditches or entering through tributaries was measured.

While gain from seepage is the rule, there are sections on nearly all of these streams where losses are found year after year, and sometimes to a considerable extent.

The Rio Grande loses from 70 to 100 cu. ft. per second in a distance of 10 miles. On the other streams the loss is less. In the case of the Platte there is some reason to think that a portion of the water reappears. In the case of the Rio Grande, neither the water thus disappearing from the river, or the water sinking in the numerous small streams reappear within Colorado.

Energy Received from the Sun.
By Prof. L. G. Carpenter, Fort Collins, Colo.

It is well known that the sunshine on our Western plains is much greater in amount than that received by the East. For nearly ten years the author has maintained observations on the intensity of the energy received from the sun (using the Arago-Davy conjugate thermometers) and also observations on the amount of sunshine. The observations show an intensity of from 7 to 17 calories per sq. m. from 8 a. m. on sunny days, or from ½ to ¼-HP. per sq. yd. It seems as reliable as the wind, which is extensively used as a source of power for small plants.

On the Testing of Steam Pipe Covers.
By Prof. Charles L. Norton, Boston.

The manifest economy attendant upon the use of some sort of a non-conducting cover to prevent loss of heat from a hot steam pipe has led to many tests of the relative efficiency of materials in use for this purpose. There is a considerable discrepancy between the reported tests upon the efficiency of the materials in most common use, and there are some new materials used for this purpose. The facts seemed to warrant further investigation of the subject.

A series of tests has been made by means of an apparatus devised by the writer. A piece of steam pipe was heated electrically by means of a coil of wire in oil within the pipe. The amount of energy necessary to keep the pipe at a definite temperature is measured. Since the energy supplied is just sufficient to keep the pipe at a constant temperature it is therefore just equal to the energy lost by the pipe. Hence from the electrical energy supplied we may compute the heat lost from the outside of the pipe. The economy of the use of some of the better covers is computed, and an examination of the fire resisting properties of the several covers is made. (Another report of these tests was given by Prof. Norton in a paper before the American Society of Mechanical Engineers at the Niagara Falls meeting in May last.—Ed.)

Methods of Determining the Frequency of Alternating Currents.
By Carl Kinsley, Instructor of Physics and Electrical Engineering, Washington University, St. Louis, Mo.

The accurate determination of the frequency is essential for the correct computation of the relations between electromotive force, current, self-induction and capacity. Since the periodicity must usually be squared, it is essential that the determination be made quickly and with but little error.

Dr. John Hopkinson was the first to use a stretched steel wire actuated by an electro-magnet and when the condition of maximum resonance was found, the periodicity was calculated from the constants of the wire and its tension.

Dr. Campbell (Phil. Mag., Aug., 1896) proposed the use of an iron rod which was thrown into resonance in the same way. From the constants of the rod and its length the periodicity was computed. The rod he found could be more easily used than the wire.

Another method capable of great accuracy and easy manipulation includes the use of a telephone in the alternating current circuit and a resonance tube by means of which the periodicity may be calculated from equations, or it can be gathered from tables already computed. (Kinsley, Phil. Mag., April, 1898.)

A very satisfactory method will be one which includes the use of a metal strip as the primary resonator whose periodicity may be changed by means of an added weight. An electro-magnet may be used as in the first two cases to set this into vibration. The periodicity can be calculated from the constants of the vibrator (Lord Raleigh, "Theory of Sound"), or a complete calibration can be made by two determinations. It will usually be more satisfactory to standardize by actually determining the periodicity of two adjustments of the resonator. The equation to be used for that purpose is

$$t^2 = D l^2 M + K l^4, \text{ when}$$

t = time of one complete oscillation.
l = distance of the sliding weight from the support.
M = mass of the slider.
l_1 = length of the vibrating rod.
D and K are the constants of this particular apparatus which may be either calculated or obtained by experiment.

The condition of resonance is obtained with great readiness and the determination may be made with as great accuracy as may be desired.

MEETING OF THE AMERICAN SECTION OF THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

The first annual meeting of the American Section of the International Association for Testing Materials was held at the Engineers' Club, of Philadelphia, on Aug. 27, with Prof. Mansfield Merriman in the chair. The first business of the meeting was the consideration of the proposed by-laws of the American Section. Mr. Gus. C. Henning explained that these by-laws were to be supplemental to the general laws of the International Association and were intended solely for government of what formed one section of the Association. The by-laws as adopted, after a careful consideration of each paragraph, were as follows:

(1) The name of this organization shall be the "American Section of the International Association for Testing Materials."

(2) The objects of the American Section shall be to unite more closely those members of the International Association living on the western continent, and to co-operate in the promotion of the purposes of this Association.

(3) Each member shall pay on the first of ———— of each year, to the Treasurer of the American Section, the sum of $2.50, annual dues for the current year. Of this amount, $1.50 shall be transmitted to the International Association, by the Secretary of the American Section, and the remainder shall be used to defray the expenses of the American Section. Any member of the American Section whose dues shall remain unpaid for the period of one year shall be reported to the Council of the International Association.

(4) The Officers of the American Section shall be, a Chairman, Vice-Chairman, Secretary and Treasurer, constituting the Executive Committee, and two members of the International Advisory Board. The American member of Council of the International Association shall be ex-officio a member of the Executive Committee. The officers of the American Section shall be elected at annual meetings and shall serve for two years.

(5) The American Section shall meet annually. The time and place of each meeting shall be fixed by the Executive Committee. Special meetings shall be called whenever the Executive Committee shall deem it necessary.

Next in order was the consideration of the problems outlined by the International Association. These problems, which are to be investigated by the International committees, and the American members who will act upon these committees, are as follows:

1. "Taking as a basis the existing conditions of inspection, to establish uniform International rules for the testing and inspection of all kinds of iron and steel." Two members to be appointed.

2. "Determinations of methods of test of the homogeneity of iron and steel with the object of eventually employing these methods for inspection." Booth, Garrett & Blair, Gus. C. Henning, Prof. Thomas Gray, Paul Kreuzpointner, A. A. Stevenson, William R. Webster.

"Preparation of uniform methods for the test of paints used for protection against corrosion of railroad structures." H. B. Seaman, J. A. L. Waddell, and two members still to be appointed.

3. "Unification of methods of test of tile pipe." One member to be appointed.

"Supplemental to the solution of the question of standard consistency of standard mortars. Determination of conditions which will produce approximately similar densities in tension and in compression briquettes." Richard L. Humphrey.

4. "Investigation of the behavior of soft steel under abnormally low temperatures." Prof. George W. Bissell.

5. "Methods of tests of welds and weldability." One member to be appointed.

7. "Collections of masses of material for the preparation of standard piece tests, with special reference to axles, tires, springs (car), cast and wrought-iron pipes, as well as the separate parts of structures." One member to be appointed.

10. "Investigations of the most practical methods of polishing and etching for microscopic study of wrought iron." Albert Sauveur.

11 and 12. "Study of the relation of chemical composition to weathering qualities of building stones. Study of the effect of the gases of combustion, especially sulphurous acid. One member to be appointed.

"Study of the relation of chemical composition to weathering qualities of roofing slates." Prof. Mansfield Merriman.

14. "Determination of rapid methods for determining conditions of constancy of volume of hydraulic bond materials." Richard L. Humphrey, William M. Maclay.

15. "In what manner can hydraulic bond materials be tested for tensile strength in the shortest period of time?" William W. Maclay, Dr. Charles F. McKenna.

16. "Testing and evaluating the resolutions of the conferences relating to the determination of adhesion of hydraulic bond materials." Booth, Garrett & Blair and one member still to be appointed.

17. "Examination of propositions for the uniform determination of the value of puzzolanas as mortars." Two members to be appointed.

19. "Investigation of the effect of fecal matter on the strength of hydraulic bond materials." Two members to be appointed.

18. "Investigations of the causes of abnormal behavior of cements as to time of setting." Two members to be appointed.

22. "How can the inspection of lumber assure protection against the growth of fungi (merulius lacrymans)?" Prof. John B. Johnson.

23. "Determinations of fundamental methods for testing lubricants (oils)." One member to be appointed.

"American Committee to report to the American Section on the present state of knowledge of impact tests." Prof. W. K. Hatt, Chairman; Prof. Edgar Marburg, James Howard.

These problems were taken up one at a time by the members and discussed in a general way. Mr. Henning first outlined the process to be followed by the committees having the problems in charge. Each committee would first investigate the problem assigned to it, and then it would be presented to the Section, and finally by that body referred to the council. If agreeable the report would then be considered in a general congress. To make the work of the most value it should be apportioned according to the desires and capabilities of the members, care being taken not to duplicate work already done. Problem 7, he stated, would require a careful study of what has been done in this country.

Mr. M. White, who has charge of the Physical Laboratory of the Bethlehem Iron Works, and was suggested as a member of this committee to consider Problem 7, stated that as the work of his company was practically all done under special government specifications, limited by government inspection, it seemed to him advisable to appoint some one from a company doing a more commercial business. In discussing this, Mr. Henning pointed out that following the first meeting of the International Association, held in Switzerland, at which Capt. Carter, U. S. A., was present, the United States government had revised its specifications and had translated, printed and distributed copies of the "Resolution of Conferences" of that and previous meeting to all its officers engaged in constructional work or testing. He had no doubt but that if properly presented and sufficiently urged by the Bethlehem Co. the government would make other changes.

In regard to Problem 17 it was decided that as the International Association had not included artificial cements it would be just as well to consider this as not including sag cements. Referring to Problem 18, Mr. Henning pointed out that this was a problem of special interest

to foreigners alone, and could be abandoned by the American Section, since so few sewers were constructed in this country out of concrete.

The other problems were read by title only, and it was suggested that there might be other practical problems which could and should be considered by the Section. If these were of general interest they could be brought to the attention of the International Association; if of local interest, they could be investigated separately by the American Section. At any time, however, inquiries could be transmitted abroad to obtain the benefit of foreign investigation, and the members should have no hesitancy in doing this or in suggesting problems for consideration.

Dr. R. G. C. Moldenke thought that the list should include a problem dealing with the qualities and properties of cast iron. Our knowledge of cast iron, he stated, stood now about where our knowledge of steel was 15 years ago, and it was time something was determined definitely. Later Mr. Moldenke's suggestion was put in form and adopted.

By way of explanation Mr. Henning stated that there would be three editions of "Materials of Construction," the official organ, published in English, French and German. In each one of these editions the contributed articles would be in the language in which it was originally written to insure accuracy and to preserve the original expression of the author. Other matter would be in English, French or German, according to the edition. Any American member desiring to contribute could do so, and his papers, if carefuly prepared, would be welcomed by the editors of the journal.

Mr. Henning also suggested that as no problem including an examination and study of impact testing machines and impact testing had been included, it should be done, and he stated that this test was used to a large extent and very successfully abroad; but that in this country it was in a very crude state, and very infrequently employed. Mr. Wm. R. Webster disputed this rather sweeping assertion, stating that during his experience he had personally inspected several thousand tons of steel rails, using an impact apparatus which gave fairly accurate results. Mr. M. White, of the Bethlehem Iron Co., stated that his experience with impact testing machines had been anything but satisfactory, and after considerable experimenting with two such machines made by the Bethlehem Co., one in the works and the other in the laboratory, he was more than ever at sea. Such tests gave absolutely misleading results. He had found bars with little or no elongation which gave good impact results and other bars with considerable elongation which made a very poor showing under the impact test. Nowadays it was not a question of absolute breaking so much as the fatiguing of metals; a question of how long would such materials stand and not altogether how much they would stand. For these reasons the drop or impact test, which practically tested the ductility of a metal, was not in the best repute. Mr. J. A. Riehle remarked that Mr. Howard, of the Watertown Arsenal, had designed an impact machine which was being manufactured by Wm. Sellers & Co. Attention was also called to several other machines, notably one at the Watertown Arsenal, built by the government, and one built by Mr. S. Bent Russell, and described by him in the Proceedings of the American Society of Civil Engineers.

In reply to the question whether the foreign sections of the International Association were considering impact testing machines, Mr. Henning said that they were, particularly in France, where Mr. Barba was conducting a long series of experiments. Russia also used this test largely. Prof. Merriman considered the subject one of live interest about which little was known and about which more should be known. Continuing the discussion, Mr. Kreuzpointner remarked that the few breakages of car axles and wheels afforded an indication that the principle employed in the "drop test" was scientifically correct, and that such a test answered very well for commercial purposes, although it could not as yet be claimed as a reliable quantity test. Upon the motion of Mr. Henning, it was finally decided to appoint a committee of three to study this question and see what has been accomplished by foreign investigators.

As this ended that portion of the programme assigned to the afternoon session, the delegates and guests adjourned in a body to the Hotel Lafayette for dinner, so that they could convene promptly for the evening session, called for 8 o'clock.

Evening Session.

Immediately after calling the meeting to order for the evening session, Prof. Merriman announced Profs. W. H. Hatt, of Purdue University, and Edgar Marburg, of the University of Pennsylvania, as two of the committee of three on Impact Testing, the third member to be announced later. The discussion of the topic "The Relation of the International Association to Producer and Consumer" was taken up, and in the absence of Mr. Dudley, Mr. W. R. Webster presented a brief paper, in which he said:

The International Association for Testing Materials occupies a neutral position to the producers and consumers, where the specifications, methods of testing, and methods of manufacture can be freely discussed by all parties, with the view of eventually adopting uniform specifications for each class of material.

The American Section of this Association, by showing the American manufacturers and consumers that it has practical work in view, will at once secure the co-operation and assistance of both parties. We are all much interested in seeing the American export trade increased, provided our materials, bridges, locomotives, etc., are shown to be as good, or better, than those produced in any other country.

At the present time the American manufacturers of steel and bridges are very much handicapped by some of the foreign specifications. In the first place, rails will not be accepted that contain more than .06% of phosphorus, and, in the second place, in many cases, basic open hearth steel will not be accepted for bridges. The railway companies are generally represented by consulting engineers, who insist that these conditions are complied with, although, in some cases, after investigation, they have accepted American practice. Are these gentlemen right to reject rails that contain over .06% phosphorus, and in refusing to use basic open hearth steel in their bridges, or, is the practice in this country right, which allows, in most cases, the use of rails containing phosphorus up to .10%, and either acid or basic open hearth steel in our bridges, provided the physical tests are satisfactory? It is right here that the American Section of this Association can be of great service, both to the manufacturer and consumer, by taking up these specifications. If the steel makers will give us freely all the information that we may ask on these matters, and our railway companies and their engineers will do the same, then we can put this information in proper shape, and bring the whole matter before the International Association.

If it can be shown that the American basic open hearth steel, made from our relatively low phosphorus iron, is as reliable as the acid open hearth steel made in this or any other country, there is no reason why the International Association should not approve of its use in bridges. And, if it can also be shown that our rails made of steel containing phosphorus up to .10%, which meet all the conditions of service in this country, and in other countries where they have been used, are as reliable as any rails made in other countries, there is no reason why the International Association should not also approve of the use of rails containing phosphorus up to .10%, provided, of course, that they meet all of the physical tests called for.

Discussing the subject, Mr. White stated that the Bethlehem Iron Co. made little basic steel. There was a prejudice against this kind of steel just as there had been against Bessemer steel, and it would take time to make people believe otherwise. In this country we use better pig iron to start with, and produce better steel, which could hardly be called acid steel when refined on a basic hearth. In response to a question, Dr. Moldenke said that a good test to determine basic or acid steel was the price. However, the province of the society was to select methods of testing either material rather than to determine which was one or the other.

Mr. H. V. Wille, Engineer of Tests of the Baldwin Locomotive Works, then read a paper and presented a number of photographs to show that the extent of segregation and the number of blowholes in steel ingots was not influenced by the process of manufacture, but were governed entirely by the shape and size of the ingot and the manner in which the steel was poured.

The discussion, which had begun to wander, was brought to the original topic, and Mr. R. W. Lesley summed up the matter in a business-like manner, saying, in substance, that times are international, especially for the United States, and our expansion in connection with recent events required that we become more international. In some industries and countries old methods are maintained, not because they are best, but simply because they are old methods. This was particularly true of some of the European countries, and it was a function of the American Section of this Association to try and have specifications and rules so altered that our goods, which were better and more cheaply manufactured, could be sold unrestricted by technicalities, both at home and abroad. In addition, international testing, to be a success, must be fairly permanent, nor should the reputation of the manufacturer be ignored in making awards.

On the same subject Mr. Henning said:

We cannot meet foreign markets unless we know foreign specifications, and it is the object of the American Section to develop and assist in the formation of a similarity of methods which would give this understanding. This should have an air of permanency to be of real value. Another of its missions was to educate foreign countries up to an understanding of what we were doing and could do. Abroad the United States was little known, and less understood, at least from the standpoint of its possibilities. And, unfortunately, this ignorance existed among engineers as well as other classes. There they are so absorbed in their own little systems and methods that they have no time for anything else, and could not realize our seemingly exaggerated statements. One of the prime objects is, therefore, to bring the producer and consumer together and convince the foreign sections of the truthfulness of our statements, the value of our methods and the quality of our products. Our manufacturers can underbid foreign manufacturers, and our goods can fill the bill, but it is necessary for our manufacturers to tell what can be done, and from the foreign members we can learn what is wanted. The same is true on this side, hence the need of a close relation between the manufacturer and the consumer, or his agent the consulting engineer. There is no danger of foreign invasion of our markets, owing to our natural advantages, our better quality of labor, and the fact that there was always a chance for advancement.

It was the opinion of a majority of those present that American manufacturers were trying to meet requirements as far as they could under existing circumstances, and that there was no doubt but that they would gladly assist the formulation of standard specifications when properly approached.

Mr. Humphrey suggested that the discussion should not be limited to steel manufactures alone, but should include all the structural branches, as was intended in the name of the Section.

As an indication of the need of standards of some sort, Mr. Kreuzpointner mentioned an incident which had come under his observation. A boiler shop which was forced to build boilers under nine different sets of specifications, while it is generally admitted that the conditions in all boilers are practicaly the same, so much so that one set of specifications would have done in this or any other shop, and the time, energy and money spent in fulfilling the other erratic specifications could be spent in perfecting the methods and materials used in the standard specifications. The trouble seemed to him to rest largely with the engineers, who, in many cases, knew considerably less about the qualities they were so carefully specifying than the manufacturers they were putting to such inconvenience.

Mr. R. W. Lesley spoke on the same topic from the cement manufacturers' standpoint. He had made a collection of specifications submitted to him to bid on, and there were 92 specifications for Portland cement and 52 for natural cements. Abroad six of the great cement manufacturing countries, turning out some 30,000,000 bbls. of cement per year, were content with six sets of specifications.

Prof. Marburg took a somewhat opposite view, and said that while standard methods of testing and standard specifications would be a good thing for the manufacturer, there was a question as to their benefit to the consumer. It was true that the multiplicity of specifications and tests now extant did put the manufacturer to expense and trouble, but it was also true that difficult specifications, if prepared by an engineer knowing his business, and not made too difficult, caused the manufacturers to improve their products. The difference in specifications was to be expected on account of the almost uncertain knowledge we have of most of our materials. From his point of view the formulation of a collection of standard specifications for all materials would not be accomplished as rapidly as some expected. However, the objects of the society were good, and there was an ample field for work.

Mr. Chas. T. Davis, Assistant Chemist, Reading R. R., mentioned an experience the Reading had had with different specifications for the material used in railway construction. Circular letters were sent to all roads in the country, having over 900 miles of track, asking for specifications of all materials used. The number of different replies received was remarkable.

Earlier in the discussion Mr. Kreuzpointner had stated that for 14 years the Pennsylvania R. R. had kept records of all boiler material, and that its present boiler specifications were based upon these data. Mr. Davis called attention to this, and stated that the Reading road had also kept similar records. The limits allowed by the two roads was appreciably different. This was mentioned merely to call attention to one of the many difficulties likely to arise in the future.

In answer to a question about time of meetings and how the proceedings would be published, it was stated that meetings would be yearly, as stated in the by-laws, unless special meetings were called by the Executive Committee. The reports undoubtedly will be published either abroad or in a special proceedings on this side. Just at present a consideration of this point was deemed premature.

NATURAL GAS IN INDIANA is considered in the last report of the State Geologist, and Mr. J. C. Leach, as supervisor of natural gas, says:

The natural gas field of the state original embraced almost 3,000 sq. miles. To-day the productive area is less than half that size. The average rock pressure was in the beginning 325 lbs., to-day it is less than 200 lbs. In the heart of the field, an area of 250 sq. miles, located in Grant, Madison, Blackford and Delaware counties, the pressure decreased 30 lbs. in 1897, and now averages but 215 lbs., while in these four counties, which are the most productive of the entire field, the average pressure is but 200 lbs. The decrease in rock pressure, added to that of an exhaustion of one-half of the original productive area and the constant encroachment of salt water toward the center of the field, all point to the final exhaustion of the supply.

CHINESE SALT-WELL BORING PROCESSES, says "The Engineer," are slow but usually effective. The salt wells and petroleum wells cover an area of about 2,500 sq. miles in the Setchouen, Yunnan and Shansi districts, and about 1,200 salt wells are now worked by companies or families. These wells are from 6 to 8 ins. diameter and from 575 to nearly 1,200 ft. deep, through rock. The drilling instrument resembles a string of thick iron sausages, with a strong tempered steel point. The cable is made of thin strips of bamboo, not twisted, and is worked from the end of a strong, elastic rod, resting on a roller and with a small platform at one end. The free end of the rod is worked by four or more men like a see-saw. The drill is withdrawn from time to time and water is poured in the hole, and the muddy liquid is extracted by a bamboo piston. To prevent the walls from caving in, cylinders of cypress wood are used, connected by nails. If the cable breaks it is fished up by a variety of ingenious hooks patiently applied; and if the iron perforator breaks, it is pounded out of the way by the slow fall of heavy weights. While an ordinary well can be bored in 6 to 10 years, some wells have required 40 years of incessant toil. The salt brine is extracted by a bamboo cylinder with a valve in the bottom, hoisted by a bamboo cable rolling over a small wheel and around a huge horizontal wheel, with buffaloes as motive power.